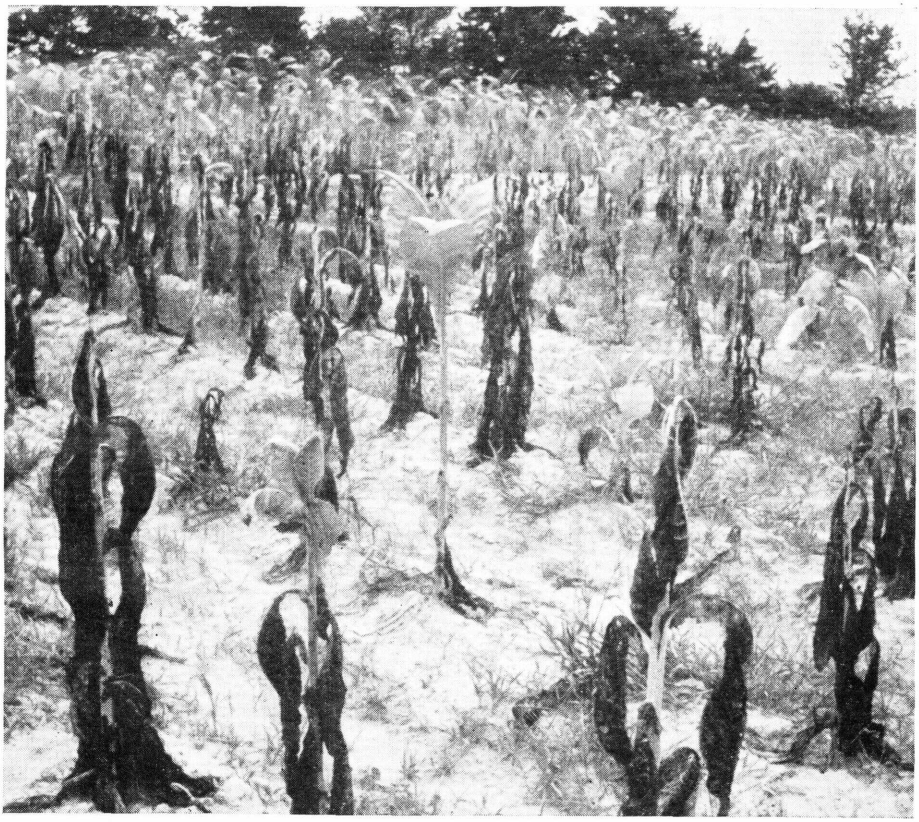
Historic, archived document

Do not assume content reflects current scientific knowledge, policies, or practices.

erve
84F

TOBACCO DISEASES and their CONTROL



Farmers' Bulletin No. 2023

U. S. DEPARTMENT OF AGRICULTURE

TO GROW a good crop of tobacco, the grower must have healthy plants to set out at the proper time. Diseases in the plant beds may reduce stands so much that the grower must look to other sources to obtain a sufficient number of plants to set his crop. This usually is very unsatisfactory.

In the field, the leaf spot diseases—wildfire, blackfire, brown spot, and frogeye—reduce both the yield and the quality. To save as much of the crop as possible the grower may harvest before the plants are ripe. Virus diseases, as mosaic, which stunt growth, also reduce quality. Root and stalk diseases are especially widespread. Many thousand acres of tobacco are affected each year by black root rot, root knot, and nematode rot. Growth vigor is reduced inconspicuously, and often the farmer may not realize what is happening. Black shank and wilt, of course, are conspicuous and the damage is well-known. Prevention and control of diseases are first essentials in obtaining satisfactory planting stock and a good crop.

Shortages or excesses of some plant-food material may cause other troubles. Malnutritional diseases in the seedbed or field consistently reduce yield and lower quality. Potash deficiencies are especially noticeable.

Curing troubles, especially house burn, are widespread in the air-cured areas. Much tobacco is destroyed or reduced in quality.

Damage may be prevented or reduced by (1) crop rotation, (2) proper fertilization, (3) use of disease-resistant varieties, (4) effective plant-bed soil sterilization, as well as sanitation precautions, (5) use of fungicides for blue mold and wildfire control, and (6) adequate provision for humidity control during curing.

This bulletin tells how to identify the main diseases, describes the most effective controls or remedies, and lists disease-resistant varieties. It supersedes Department Bulletin 1256, Tobacco Diseases and Their Control, issued in 1924.

Washington, D. C. Issued November, 1950

For sale by the Superintendent of Documents, U. S. Government Printing Office
Washington 25, D. C. - Price 25 cents

TOBACCO DISEASES AND THEIR CONTROL

By E. E. CLAYTON, *principal pathologist*, and J. E. MCMURTREY, JR., *principal physiologist, Division of Tobacco, Medicinal, and Special Crops, Bureau of Plant Industry, Soils, and Agricultural Engineering, Agricultural Research Administration*

CONTENTS

DEVELOPMENT AND CONTROL OF TOBACCO DISEASES

TOBACCO DISEASES are serious production problems in all areas. Growers have good reasons for believing that these problems have multiplied and intensified in recent years. In earlier days when

growers used newly cleared land not only for plant beds but also for growing much of the field crop, soil-borne diseases did not become destructive. New land for both plant beds and fields is now largely a thing of the past. Then, too, the introduction and wide dissemination of black shank and blue mold during recent years have increased disease damage.

Until quite recently control measures for tobacco diseases have been notably ineffective. Beginning about 1910, however, research on tobacco problems was well organized in a few State experiment stations and the United States Department of Agriculture, and this work soon began to yield results. An early achievement was the development of a method of soil sterilization by steam for tobacco plant beds. Steaming made it possible for growers in the northern areas to establish and maintain permanent plant-bed locations. During the decade 1911–20 resistance to the common black root rot disease was discovered, and the first of a series of root-rot-resistant commercial varieties was released. In the next decade, 1921–30, resistance to black shank disease was established. During the period 1931–40 effective fungicidal treatments for blue mold were developed. Much progress was made in this period, also, in the development of chemical soil treatments for tobacco plant beds. These soil treatments were designed to destroy both weed seeds and disease germs. This period was notable for the development of varieties of tobacco that are resistant to mosaic and bacterial (Granville) wilt. Since 1940 varieties that have high resistance to the bacterial leaf spots—wildfire and blackfire—have been developed.

The foundation has now been provided for a very effective program of tobacco disease control, based primarily on disease resistance but supplemented by other measures. It would be a mistake for growers to believe that disease resistance eliminates need for disease control by rotation, for example. It is true, however, that as resistance to major diseases is introduced into the various types of tobacco, rotations can be shortened and made much more effective.

The purpose of this publication is (1) to discuss the general practices of value to the tobacco grower in developing his program of tobacco disease control, and (2) to identify the various diseases and tell briefly what is definitely known about the control of each. Much information that is important only in certain localities is necessarily omitted. Growers can obtain this from their county and State extension service specialists.

LOSSES FROM TOBACCO DISEASES

Tobacco diseases reduce both the yield and the quality of the crop. These direct losses are conservatively estimated at 15 percent of the crop. On the basis of 1948 farm values, this loss was about $150,000,000. In addition to causing direct losses, diseases increase production costs in many indirect ways. Following the appearance of blue mold in 1931, the growers throughout the flue-cured tobacco area almost doubled the size of their plant beds. This form of insurance costs about $4,000,000 annually. Again, blue mold often delays transplanting 2 to 6 weeks, and this delay may result in a reduced yield

of inferior quality. Soil-borne diseases force growers to adopt long rotations and often to use land not well adapted to the crop.

Such well-known diseases as blue mold, bacterial wilt, and wildfire are of great economic importance, but the many less conspicuous troubles also cause enormous losses.

Some of the greatest total losses are caused by diseases that are not conspicuous. Root knot and nematode root rot do not have a conspicuous effect on top growth except in the most severely affected fields. However, these diseases cause damage each year to some 500,000 acres of tobacco in Virginia, North Carolina, South Carolina, Georgia, and Florida. In North Carolina the loss from root knot alone was estimated in 1942, an average year, at $7,200,000. Mosaic is another disease that reduces the yield and quality but does not kill plants. Because the disease is so widespread, however, the aggregate losses are large.

GENERAL CONTROL MEASURES

SANITATION

Tobacco growers suffer heavy losses through carelessness and failure to understand the need for precautions to avoid the introduction and spread of diseases. The location of plant beds is important. They should not be near tobacco barns or in a place that might be reached by drainage water from an old tobacco field.

Refuse tobacco is excellent fertilizer for most crops, but not for tobacco. It should never be applied to tobacco beds. In some areas cured tobacco is stripped and otherwise handled in the spring when plants are growing in the beds. Under no circumstances should the grower work with the old crop and then go to the beds to weed or pull plants. To do this would risk spreading mosaic disease to the new crop plants. A disease such as black shank is readily spread by water; in areas where it occurs growers take a chance when they water their beds from ponds or streams.

Probably more diseases have been spread by purchase or exchange of plants than in any other way. Bringing plants from other farms and other areas each year spreads many troubles, which often remain to cause serious damage in succeeding years. The careful grower makes every effort to raise his own plants.

Effective sanitation applies primarily to the bed and the plants, because transplanting healthy plants is the first important step in producing a good crop. Bed areas are not large, and special attention to their selection and care is most practicable and profitable.

PLANT-BED CONTROL MEASURES

Disinfection of Construction Materials

As growers generally know that disease infections may live over in the soil, they either use some method of soil sterilization or change bed sites frequently. However, disease infection may live over on old cotton, sash, boards, or logs. Root rot, damping-off, blackfire, wildfire, and other disease organisms will survive in this way. Therefore, if diseases are present in the beds, the materials that are to be used again next year for bed construction should first be disinfected. A

good procedure is to drench boards, logs, or sash with a 1-to-25 solution of formaldehyde [1] (commercial 37–40 percent), then pile and cover these materials to hold in the fumes for 24 hours. Cottons can be disinfected by boiling in water for 1 hour. Probably the most practical procedure, however, is to wet the cotton thoroughly with a copper spray as described under wildfire bed control (p. 26). In the rare cases where black shank occurs in a plant bed it is advisable to discard all bed materials rather than to take a chance on introducing the infection into next year's beds.

Soil Sterilization

Successful plant production requires a plant bed be properly located and that the soil be reasonably free from weed seed and completely free from the germs of black root rot, root knot, and other serious diseases. Growers originally met these needs by clearing new land for the beds each year. Suitable new locations have now become scarce, and many growers are forced to use an old bed site or an area in an ordinary cultivated field. Some have established permanent plant beds. These changes have greatly increased the need for some form of soil sterilization that will eliminate weeds and soil-borne diseases. The methods now in use include steaming, burning, and chemical disinfection.

No matter what method of soil sterilization is used, it is desirable to prepare the plant-bed soil completely before treating. After treatment the bed should be framed at once and protected against washing, by ditches if necessary. If the same bed area is to be used again, it should be cleared as soon as the crop has been transplanted. Manure should then be applied, and the entire area disked and seeded to soybeans, velvetbeans, cowpeas, or some other cover crop. Cover crops must be disked in during late August or early September to be completely decayed by treatment time in the fall. It is necessary to treat beds each year.

Burning

Burning was the earliest method developed for sterilizing the plant-bed soil, and it is still used extensively. When this method is used the

[1] CAUTION

The chemicals mentioned in the treatments are injurious to man and animals when taken internally; some of them are extremely poisonous. Therefore, care should be used in handling them to prevent their contact with the mouth, eyes, or nostrils. When these chemicals are used in dust form, care should be taken not to inhale them. When large quantities of solutions are used, oiled leather gloves and a rubber or oilcloth apron should be worn. Care should be taken in pouring out the used solution to see that it soaks into the ground and does not stand in puddles. All vessels should be cleaned thoroughly after use, and clothing and hands should be washed.

bed area should be cleared of all leaves and trash during the early winter. Shortly before seeding time the brush and wood should be piled over the entire bed area to a depth of 3 to 4 feet (fig. 1). A quiet, dry morning should be picked for the burning.

To conserve wood, a fire may be built at one end of the bed, with poles or a length of woven-wire fencing beneath. After one area is

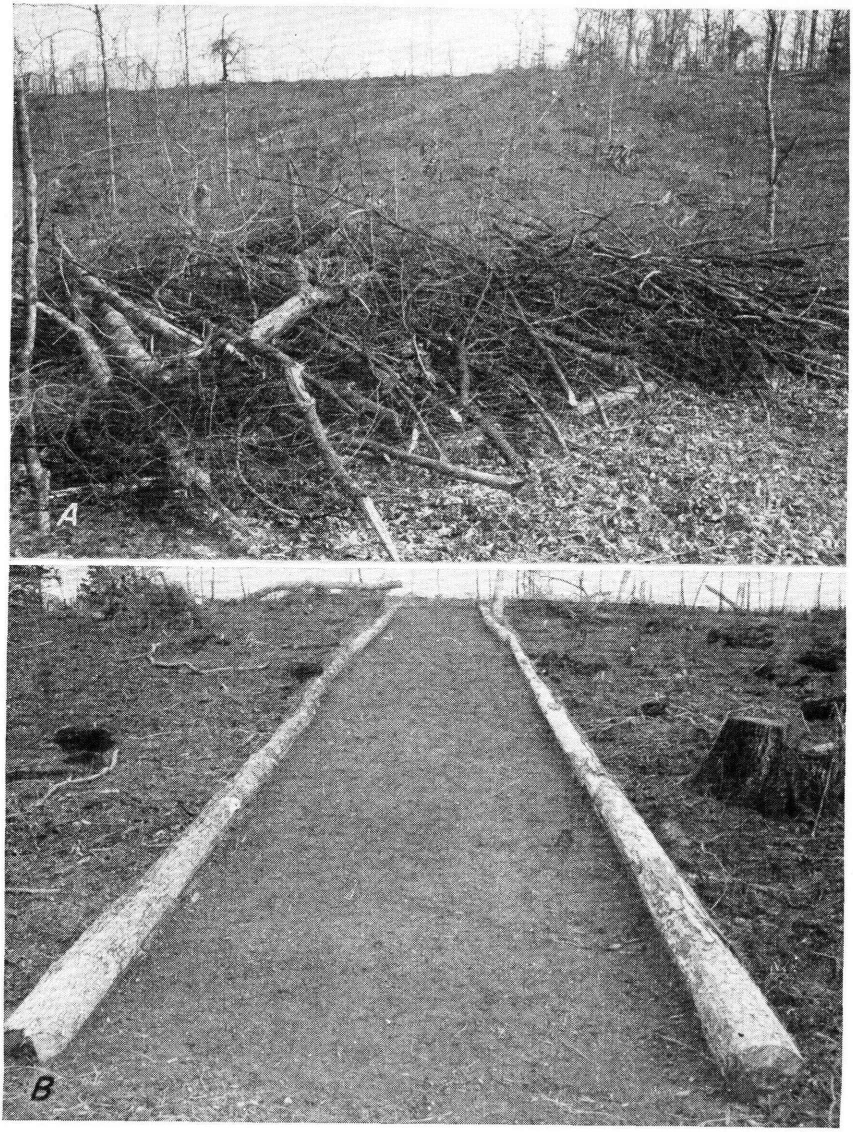


Figure 1.—Plant-bed sterilization by burning. *A,* Entire bed area has been covered with brush. When this brush burns, it will kill weed seeds and disease germs in the surface soil. *B,* Bed has been burned, prepared, and seeded.

heated, the fire is pulled to an adjoining area, and so on for the entire bed. Thorough burning heats the soil effectively to a depth of 4 inches, but many growers use so little fuel that only the thin surface layer of soil is sterilized. Such treatment cannot be expected to eliminate disease germs effectively.

In some areas growers prepare the plant bed and then cover it to a depth of 3 to 4 feet with cotton stalks or similar material. This makes a short hot fire that will destroy weed seed to a depth of not more than 1 inch. Even this limited treatment is well worth while, provided the soil is not worked in such a way that viable weed seed will be brought to the surface.

After a bed is burned, the coarse material is raked off. The ashes remaining provide potash and other mineral fertilizers. Nitrogen and phosphorus must be supplied.

PORTABLE PLANT-BED BURNER.—Because of the increasing scarcity of wood, a portable type of plant-bed burner was developed. This reduces fuel requirements about two-thirds, but it requires solid wood and not brush. The burner, or furnace, consists of a sheet-iron firebox 9 feet long, 3 feet wide, and 18 to 21 inches high, with a pan 4 to 8 inches deep on top. The firebox is open at one end and has a smokestack at the other. Wheels and handles make it movable.

The burner is placed in the center at one end of a bed 9 feet wide. The soil beneath should be loose. The soil from the 3- by 9-foot area on one side of the burner is removed to a depth of 3 inches (fig. 2, *A*) and placed in the pan, where it is heated until practically dry. The temperature throughout should be 190° F. or higher. This may require up to 1 hour. Usually it takes about 30 minutes, depending on the hotness of the fire and the quantity of moisture in the soil. The more moisture there is in the soil, the longer it will have to be heated. To insure even heating, the soil is turned (fig. 2, *B*) at least twice; after treatment, it is piled in heaps so that it will retain the heat longer. The 3- by 9-foot strip on the other side of the burner is next treated. Meanwhile the area beneath will have been sufficiently heated. After all preparations have been made, two men can treat a 100-square-yard plant bed in 1 day. The portable plant-bed burner is intended primarily for weed control.

Steam Sterilization

Full information about steam sterilization is given in Farmers' Bulletin 1629.[2] This method is especially adapted to permanent plant beds and has long been used extensively in the more northern tobacco areas. Steam boilers have been practically unavailable throughout the South, and are not common anywhere.

The boiler should have at least 20-horsepower capacity and should provide 100 to 125 pounds of steam pressure at the boiler. The soil must be moderately dry and loose to facilitate steam penetration. Steam is piped into a metal pan constructed of No. 16 galvanized iron or other suitable material. It is advantageous but not essential to have two pans, so that one can be left in place to retain the heat while the other is being used to treat an adjacent area (fig. 3).

---

[2] Steam Sterilization of Soil for Tobacco and Other Crops. U. S. Dept. Agr. Farmers' Bul. 1629. 1937 (rev.).

Minimum sterilizing time under most favorable conditions is 20 minutes—30 minutes is usually better. Pans are constructed to cover 50 to 110 square feet. Steaming requires about 1 pound of coal per square

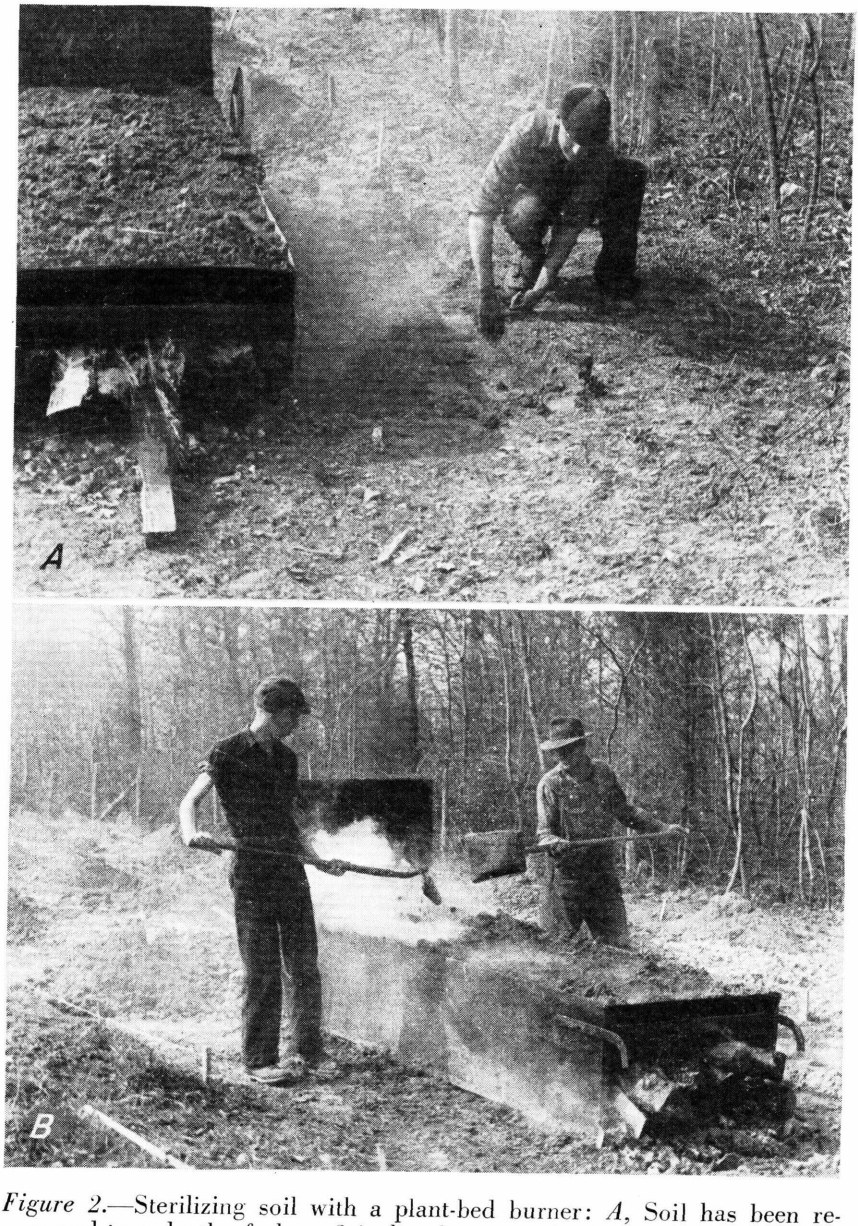


Figure 2.—Sterilizing soil with a plant-bed burner: *A*, Soil has been removed to a depth of about 3 inches from a 3- by 9-foot strip at right of burner and placed in the heating pan. *B*, Soil in the pan is being turned to insure uniform heating. Note steam rising from soil.

892178°—50——2

foot of bed surface. The work can be done either in fall or spring, whenever the soil is in proper condition. In general, fall steaming is preferable.

Urea and Calcium Cyanamide Treatments

Urea [3] at the rate of 1 pound per square yard destroys both weed seeds and soil-borne diseases, such as root knot and black root rot. Calcium cyanamide,[4] at the same rate, is effective against weeds but not diseases. A combination of urea, 1 pound, and cyanamide, ½ pound per square yard of bed, gives as good disease control as the urea alone and somewhat better weed control and plant production. When weed control only is desired, treatment with cyanamide, 1 pound per square yard, is suggested. If both weed and soil-borne-disease control are needed, the combination urea-cyanamide treatment is recommended (fig. 4).

Urea and cyanamide treatments are particularly well suited to the light sandy soils of the Coastal Plain area of North Carolina, South Carolina, Georgia, and Florida. If used on heavier soils, there is great danger that the residue of nitrogen will not be sufficiently leached out by seed-sowing time in the spring. Beds should be treated when

[3] Sold as Uramon. The use of this trade name and of those for chemicals discussed later in the treatment of tobacco beds and seed does not mean the Department guarantees the standard of the product nor imply that subsequent products may not be as effective in controlling the diseases. A list of manufacturers of these chemicals can be supplied by writing to the Plant Industry Station, Beltsville, Md.

[4] Sold as Cyanamid.

Figure 3.—Steam sterilizing a tobacco plant bed. Steaming is in progress with one pan (left); the other pan is being moved to a new area.

the soil is in good condition to work and at least 60 days before seed sowing. In general, chemicals can be applied any time that is suitable between September 1 and November 1. Early October is a favorable season in most areas.

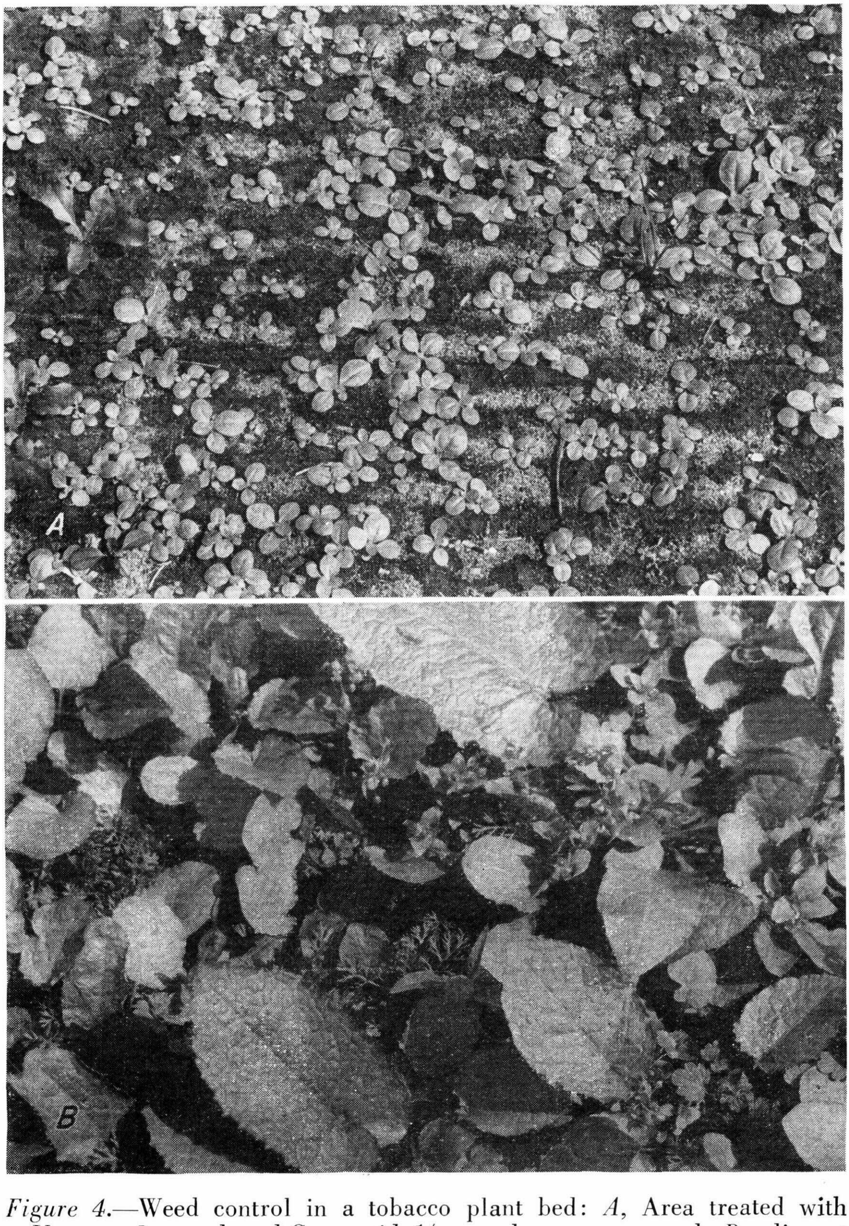


Figure 4.—Weed control in a tobacco plant bed: *A,* Area treated with Uramon, 1 pound, and Cyanamid, ½ pound per square yard; *B,* adjacent untreated area.

Prepare the plant-bed area for treatment by plowing and disking. Level the ground carefully (fig. 5), mark the border of each bed, and divide with cross marks to give areas of equal size. This facilitates uniform distribution of the chemical. Broadcast two-thirds or three-fourths of the chemicals and work this quantity in 4 or 5 inches deep. Use a disk, a shovel-type cultivator, or any method that will thoroughly mix chemicals and soil (fig. 6). Work the ground over repeatedly to insure thorough mixing. Then broadcast the remaining one-third or one-fourth of the urea and cyanamide and work this into the surface inch of soil with an iron rake or some other tool that does not go deep. Do not just scatter the materials over the surface of the soil and leave it. If weather and soil remain dry after the chemicals have been applied, wet the soil with water to a depth of 5 to 6 inches. This requires from 200 to 300 gallons of water per 100 square yards. Treated beds should be ditched if necessary to prevent water from outside areas washing over the bed and bringing in fresh, living weed seed.

Care of Urea- and Cyanamide-Treated Beds.—Weed control by these chemical treatments is most effective in the surface of soil, and many weed seeds that are 3 to 6 inches deep will still be viable. It is important to avoid bringing these seed to the surface where they can sprout and grow. Tools that will go deeper than 1 to 1½ inches should not be used after the chemicals are applied in the fall. Special care should be taken when the fertilizer is worked in prior to seeding. Weeders and hand rakes are good tools.

Both urea and cyanamide are high-nitrogen fertilizers. Much of the nitrogen is leached out during the late fall and winter, but even with light sandy soils enough nitrogen will usually remain to supply the needs of a crop of plants. The danger is that the residue will be too large and hence cause injury and a poor stand. It is advisable to reduce the amount of nitrogen supplied in the fertilizer to not more

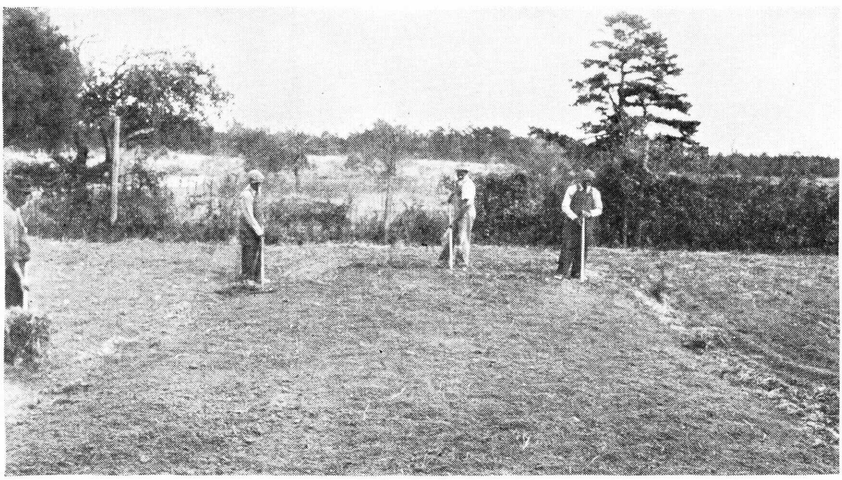


Figure 5.—Preparing the plant bed for chemical treatment. The soil has been thoroughly worked, trash removed, and the bed area blocked. It is now ready to treat.

Figure 6.—Treating the plant bed with the combination urea-cyanamide mixture. The first two-thirds of the chemical is being thoroughly mixed with the soil.

than one-half the amount that would be given a bed not chemically treated.

Beds treated with urea and cyanamide should receive special attention after sowing and until the plants are up. If the winter is dry, and particularly if there is dry weather after seed sowing, it is essential to water. This watering must continue until a good stand of plants has been obtained. By careful attention to watering during the seed-germination period, it is often possible to obtain successful results with the chemical treatments in soils that would otherwise be too heavy or too dry. If early plant growth is retarded here and there and leaves are dark green, there probably is too much nitrogen. The best remedy is to water these areas thoroughly.

Many growers now use the same plant beds several years, treating them each fall. A large number of growers do not touch the bed area from the time the last plants are drawn in the spring until late summer—2 or 3 weeks before treatment time. During the interval a solid mass of grass and weeds matures a tremendous crop of seeds (fig. 7).

Figure 7.—The last plants were pulled from this plant bed in mid-May; it is now mid-July. The tremendous crop of weed seeds that is being matured makes it doubtful that the next chemical treatment in the fall can give adequate weed control.

This is the usual explanation when growers complain that the treatment no longer gives them adequate weed control. The treatment should reduce weeds by 85 to 90 percent. If, because of careless farming, the potential weed crop averages 500 seedlings to the square foot, even a normal kill will not be adequate. Bed areas that are to be used again should be disked within 2 weeks after the last plants are drawn and planted to cowpeas or some other large-seeded crop that will come up quickly and cover the ground. The cover crop, in turn, must be worked in 4 weeks before treatment time in the fall, so that the plant residues will be well decayed and the ground firm at the time chemicals are applied.

Chloropicrin

Of all chemicals so far tested for tobacco plant-bed soil sterilization, chloropicrin (Larvacide or tear gas) is the most effective combination nematicide, fungicide, and bacteriacide. It does not give good weed control unless special precautions are taken to seal the soil surface and hold in the fumes. Nor is it pleasant to handle. The best treatment time is in the fall when soil temperatures are between 55° and 70° F. Treatment in late fall, when soil temperatures are lower, is not advisable. Bed areas should be worked up 10 days to a week in advance of treatment, to allow time for settling. If manure is to be used it should be added at this time. The soil should not be dry. Moisture conditions that would favor planting are about right. In the event of drought during the normal fall-treatment period, the bed should be thoroughly watered at the time the soil is worked up.

Chloropicrin is applied 3 to 5 inches deep. With a hand injector, injections of 3 cubic centimeters (approximately ½ teaspoonful) are made 10 inches apart.[5] This totals 14 to 15 pounds per 100 square yards. With clay soils, in general, higher rates and deep applications are preferred. Good disease control can be obtained with chloropicrin treatment merely by wetting the soil surface promptly after treatment. To obtain weed control, however, the gas must be held in for several days. Wet covers of burlap bags, several layers of old cloth, wet peat moss, or other similar materials will be satisfactory for this purpose if kept moist. Beds treated in the fall should have no trace of chloropicrin by seeding time in the spring. The presence of the gas can be readily detected by smelling.

Chloropicrin bed treatment has been recently used quite extensively in Connecticut. The procedure there is as follows: Clean the beds of all weeds and trash; apply manure, if it is to be used; and work the soil 8 inches deep. If the soil is dry, moisten it a week to 10 days in advance of treatment. Apply the chloropicrin with a continuous-flow machine, 3 to 4 inches deep, and 14½ to 18 pounds per 100 square yards. Promptly rake the beds level and water them. Then cover them and keep the cover moist for 3 days. A common covering consists of three thicknesses of old shade cloth; another cover consists of 1½ inches of moist, weed-free peat. By using machine application it is possible to treat as much as an acre of beds in a day. Results in weed control, disease control, and plant production have been comparable to those obtained with steaming.

Other Chemical Treatments

The materials and methods previously discussed have been tested over a long enough time to provide fairly complete knowledge of their possibilities. Other materials are available that may be used for treating tobacco plant beds, but knowledge of these is less complete.

ETHYLENE DIBROMIDE [6] AND DICHLOROPROPENE-DICHLOROPROPANE [7].—These fumigant materials control nematodes more effectively than urea, but they do not destroy black root rot infection or weed seed. Combinations of the fumigants with formaldehyde, a fungicide, and cyanamide, a weedicide, are compatible.

A recommended rate of application of the fumigants for plant beds calls for 2 to 3 quarts of the usual commercial mixtures per 100 square yards. This is equal to 2 to 3 cubic centimeters per square foot. Materials may be plowed in or applied by machine or hand applicator; or the fumigant can be emulsified with a synthetic soap and water. In this event dilute the amount of material required for 100 square yards in 100 gallons of water and apply with a sprinkling can.

FORMALDEHYDE.—Formaldehyde is one of the oldest materials used for chemical sterilization. It is usually diluted 1-to-50 with water, and the solution is applied at the rate of 2 quarts per square foot of

---

[5] For precautions in using such chemicals, see footnote 1, p. 4.

[6] Dowfume W–40 is one of several commercial mixtures. It contains 20 percent by volume of ethylene dibromide.

[7] Supplied as D-D or Dowfume N. These are mixtures of dichloropropene and dichloropropane.

soil surface. The soil must first be worked thoroughly, and it needs to be fairly dry to absorb the required amount of the solution. This treatment is effective against all the common soil-borne tobacco diseases except root knot. It is not effective against weed seeds.

Acetic Acid.—Acetic acid is used in the same manner as formaldehyde, at the rate of 8 pounds of 56 percent acid in 50 gallons of water, and will give about the same disease control.

Methyl Bromide.—This material has given excellent weed control at the rate of 9 pounds per 100 square yards of bed. In some tests it has effectively controlled nematodes. Methyl bromide is usually supplied under pressure in 1-pound cans.

The treatment procedure is as follows: Work up the soil thoroughly and level it. Then cover entire area with crossed tobacco sticks, cornstalks, or other material that will support a gasproof cover 3 or 4 inches above the ground. Place a metal trough to hold the methyl bromide in each 300-square-foot area, and prepare to tube the methyl bromide from container to trough. Cover the entire bed area with a tight gasproof paper or plastic fabric and seal the edges tightly with soil.

The success of the entire operation depends on a gastight cover. A special puncturing instrument, plus a tube, is used to transfer the methyl bromide from cans to the troughs under the cover. The recommended treatment time is 48 hours when soil temperatures are between 50° and 60° F. and 24 hours with temperatures above 60° F. Seed may be safely sown a few hours after the treatment is completed. Methyl bromide treatments have been used successfully in both the fall and the spring.

Methyl Bromide is a poisonous gas and the detailed precautions furnished with the material should be closely observed.

Reminders

It is important to remember that beds treated with urea and cyanamide should receive much less nitrogen in the fertilizer because the treatments leave behind a large residue of nitrogen. Beds treated by steaming or burning, or with other chemicals such as chloropicrin and methyl bromide, should receive the normal nitrogen fertilization. Most of these chemicals are poisonous and should be handled with care. Hands should be washed promptly if wet by the solutions, and clothing or shoes that become wet should be removed.

SEED TREATMENT

In general, there is little evidence that tobacco seed treatment is always necessary. If, however, wildfire or blackfire is present in the field, chemical seed treatment is recommended as a precaution. Seed should be cleaned to remove all trash before it is treated. The treatments that can be used are either corrosive sublimate (bichloride of mercury) or silver nitrate, 1 part in 1,000 parts of water. Use glass, earthenware, or wood containers. Soak the seed for 15 minutes and rinse it thoroughly if corrosive sublimate has been used. Rinsing is not necessary after treatment with silver nitrate, and this treatment should always be used if the seed is to be bulk-sprouted before sowing.

If seed is dried following treatment this should be done at room temperature.

SOIL FUMIGATION IN THE FIELD

Fumigation treatments for the control of nematode diseases—root knot and root rot—are at present being used extensively in the Florida-Georgia shade-grown tobacco area. These treatments are also being tried by many growers of flue-cured tobacco. Depending on the severity of the nematode infestation, yields have been increased as much as 500 to 600 pounds of cured leaf per acre. Where there is no nematode damage, increase in yield cannot be expected from fumigation. Much remains to be learned about these treatments which may sometimes lower the quality of flue-cured tobacco because they may result in an increased proportion of low-grade red leaf.

The fumigants commonly used are ethylene dibromide (Dowfume W-40) and dichloropropene-dichloropropane (D–D) mixture. They can be applied either broadcast or in the row. The recommended rate of application for broadcast treatment is 17 to 20 gallons per acre, and for row application 7 to 10 gallons per acre. Broadcast applications should be made about 30 days before planting. Row applications are put in about 2 weeks before planting, and the fertilizer is applied at the same time. However, when this is done a split-fertilizer application is desirable, with at least one-third of the fertilizer applied after planting. Also, with row application it is possible to stir the bed with a small tongue plow and then rebed lightly just before planting. Chemicals should be put in 7 to 10 inches deep when the soil is in good working condition and when soil temperatures are 45° to 60° F. Excessive quantities of crop residue, such as cornstalks or coarse manure, are undesirable; they hinder the applicator machine and form channels through which the vapors escape too rapidly. After either broadcast or row treatments the soil should be packed with a drag or heavy roller. Cool temperatures or heavy rains after treatment lengthen the period required for the elimination of vapors from the soil. On the other hand, light rains immediately after treatment have increased effectiveness.

Fumigation materials must be applied uniformly and accurately. A simple way to regulate dosage is to fill the tank of the treatment machine partly with kerosene or gasoline, then run the machine at a normal rate of speed until 2 to 3 gallons have been discharged, measure the distance covered, and adjust accordingly. For example, with rows 4 feet apart and a 10-gallon-per acre row treatment, 1 gallon of fluid is required for 1,089 feet of row.

The purpose of field fumigation is not to eliminate the nematodes completely, but rather to reduce their numbers greatly and to permit the development of a large, relatively healthy root system during early summer and midsummer. In many tests toward the end of the crop season the roots in treated plots become heavily infested with nematodes. This does not affect the yield of the crop but does provide a heavy carry-over infection. In general, growers who treat expect to repeat the treatment each year.

892178°—50——3

CROP ROTATION

Rotation of tobacco with other crops involves important nutritional and disease-control problems. In the burley and northern cigar-leaf areas, clovers are extensively used in tobacco rotations, and the residues of organic nitrogen are desirable. In the flue-cured area such legumes as peanuts, soybeans, and cowpeas are widely planted on tobacco land, but, except on very thin sandy soils, it is usually best to have a non-leguminous crop immediately precede the tobacco. Any considerable residue of organic nitrogen is likely to impair quality. As diseases that affect tobacco also attack other crops, it follows that the use of these crops may increase the tobacco-disease hazard.

Diseases, and the crops that encourage their development, are as follows:

Bacterial (Granville) wilt.—Peanuts, Irish potatoes, peppers, tomatoes, and various weeds.

Fusarium wilt.—Sweetpotatoes.

Southern stem and root rot.—Peanuts.

Black root rot.—Clovers, lespedeza.

Brown root rot (northern).—Timothy.

Nematode root rot.—Corn, cotton, and crabgrass.

Root knot.—Sweetpotatoes, tomatoes and truck crops, cowpeas, soybeans, Austrian Winter peas, blue lupine, clover, and alfalfa.

Virus diseases (mosaic, ring spot, vein banding, etch, and streak).—Irish potatoes, clovers and other legumes, and native weeds, such as groundcherry and horsenettle.

It is apparent that the cropping system must be adapted to the particular disease problem as well as to other conditions. Also, rotation can be used most effectively in conjunction with disease resistance and other control measures. The wilt and black shank varieties are not completely immune, and with continuous tobacco culture the level of soil infection can be raised to a point where even resistant varieties suffer appreciable loss. With a 2- or 3-year rotation these same varieties can be grown safely. The common idea that the introduction of disease-resistant varieties does away with the need for rotation is unfortunate. The development of such varieties does enable growers to use shorter rotations more successfully.

DISEASE-RESISTANT VARIETIES

Disease control by the breeding of resistant varieties is the important development of recent years. Through resistance it has already been possible to obtain effective control of such diseases as black root rot, black shank, and bacterial wilt. The production of the new varieties has been slow, because resistance must be combined with quality, yield, and other desirable plant characters. Furthermore, it is obvious that the grower needs varieties resistant to not one disease, but rather varieties resistant to a group of diseases; for example, flue-cured varieties resistant to black shank, bacterial wilt, nematodes, fusarium wilt, and blue mold. It is encouraging that adequate resistance to all these diseases is available as the result of much research. The task of supplying the combined resistance available in single commercial varieties has only begun. The following major disease-resistant varieties are now in use.

400 and Yellow Special. These varieties are similar and they are adapted particularly to the western North Carolina-Virginia flue-cured area. They are not highly disease-resistant, but they have some resistance to a number of diseases—black root rot, root knot, nematode root rot, bacterial wilt, Southern stem and root rot, and leaf spot.

Oxford 1 is a variety of the Virginia bright-leaf type, moderately resistant to black shank. Its resistance to black shank is usually adequate when tobacco is grown in a 2- or 3-year rotation. With continuous culture higher resistance is required.

Vesta 30 and 33 are highly resistant to black shank and they have stood up well under very severe disease conditions.

Oxford 26 is highly resistant to bacterial (Granville) wilt. On soils of moderate fertility, quality has been excellent. The leaf has tended to be too dark on fertile soils.

Dixie Bright 27 is an improved Oxford 26. The leaf is less brittle, and the yield greater.

Dixie Bright 101 has a combination of high wilt resistance, moderate black shank resistance, and good yield.

Dixie Bright 102 has both high wilt and high black shank resistance. It is not a high-yielding variety, though quality has been good.

Vamorr 48 and *Vamorr 50* are flue-cured varieties resistant to mosaic and black root rot.

Flue-cured tobacco is produced over a wide area from Virginia to Florida, inclusive. The foregoing varieties are not equally suited to all parts of this area, and detailed information as to their suitability for any particular locality should be obtained from the county agent or State extension service.

BURLEY

Kentucky 16 and *Kentucky 41A* are heavy-yielding types, resistant to black root rot, that are generally planted in all burley areas.

Burley 1 is a new variety that yields about the same as the preceding. It is highly resistant to root rot and grades out less noncigarette leaf.

Kentucky 56 is a good quality burley that is resistant to mosaic and black root rot.

DARK FIRE-CURED AND AIR-CURED

Kentucky 150 and *Kentucky 160* are dark tobacco varieties that are resistant to mosaic disease.

CIGAR

R. G. is now the standard black-shank-resistant shade-wrapper variety in the Florida-Georgia area.

Connecticut 15 is a new variety that is suited to the New England shade-wrapper area. It has high resistance to black root rot. Also it produces 20 to 25 marketable leaves, as compared to 15 to 18 for the ordinary shade variety.

Havana 142, *211*, *307*, *322*, *K1*, and *K2* are cigar-binder types that are highly resistant to black root rot. At the present time Nos. 142 and 307 are widely grown in Wisconsin, and No. 211, K1, and K2 are extensively planted in Connecticut.

PLANT-BED DISEASES

DAMPING-OFF (BED ROT)

Damping-off [8] is caused by organisms that are present in most soils. A destructive type affects very young seedlings just as they are emerging, or very soon thereafter. Good initial stands often seem to fade away, and the loss is usually attributed to frost, excessive moisture, or other natural causes. Actually the seedlings may be shriveled by fungus attack, and the tiny plants dry up and disappear. A second type of damping-off occurs later and decays the plant stems at the ground surface. Diseased areas are more or less circular. The disease is favored by high moisture and by excessive use of cottonseed meal, chicken manure, and other organic fertilizers.

The damping-off organisms are likely to be prevalent in old bed or garden locations. Wooded and grassland areas, on the other hand, are usually quite free from damping-off. Soil sterilization by steam and chemical treatments with chloropicrin or formaldehyde will generally free the soil from damping-off.

A simple formaldehyde treatment recommended by the Connecticut Agricultural Experiment Station is as follows: After the plant bed is ready to sow, sprinkle the soil surface with a solution of 1 pint formalin to 1 gallon water, at the rate of 10 to 12 gallons per 100 square yards. Rake this with the top 3 inches of soil, and seed. Do not exceed the recommended amounts.

Reinfection from unsterilized soil or from other sources is not uncommon and should be guarded against. When the conditions permit, the spread of damping-off may be checked by removing covers and allowing the plants and ground surface to dry. Regular spraying of the beds, as described for blue mold, gives good control of damping-off, providing applications are begun early enough.

BLUE MOLD

Blue mold [9] became established in the tobacco-producing area of the Southeast in 1931. Effective methods for control were not known at that time. Growers attempted to meet the problem by sowing more beds, hoping that enough plants would survive. The disease was most severe in Georgia, North Carolina, and South Carolina, and by 1935 the growers in this region were generally planting about 100 square yards of plant bed per field acre—about twice the amount sown prior to the appearance of blue mold. Results were often very unsatisfactory, as the plants that survived mold attack were frequently delayed 4 to 6 weeks. At present, with effective control measures available, it is much more practicable to sow moderate-size bed areas and to give them regular blue mold protection. In the flue-cured area, good, well-cared-for beds may yield 30,000 or more transplants per 100 square yards.

---

[8] Damping-off early in spring is largely caused by *Pythium debaryanum* Hesse, later by *Rhizoctonia solani* Kuehn. Similar troubles are caused by other species of *Pythium* and strains of the soft-rot bacteria.

[9] Caused by *Peronospora tabacina* Adam.

It is not possible to forecast in advance how destructive blue mold may become. This depends on the weather. For example, in Georgia in 1949 blue mold appeared early, and this favored a severe attack. However, the disease was checked by unusually warm weather during February, and damage was minor. In North Carolina and Virginia in 1949 the plants in the beds encountered unusually cool weather throughout April, and the blue mold outbreak was most destructive. In addition to cool temperatures, blue mold is favored by moist, cloudy weather, but not by heavy rains.

The only safe procedure in areas where mold is likely to be destructive is to begin a regular schedule of blue mold treatments as soon as the disease is reported in the locality. The control program should be continued as long as the danger of damage persists. In most cases this will be until the crop is set.

Preparation for blue mold control should begin with the selection of the bed area. The infection can live over in old bed soil. Growers in Georgia and South Carolina who seed old bed areas should be particularly on guard against a very early occurrence of the disease. The danger of bed carry-over can be reduced by seedbed soil sterilization with steam or the urea-cyanamide combination.

Beds that are to be sprayed or dusted for blue mold should not be more than 4 yards wide, and 3 yards is better. Seed should be sown during the period recommended for the area, and not extremely early as is often done. Early-sown beds often provide plants on which the disease can multiply and spread early. Hence, they may be a source from which many other beds in the locality become infected.

The disease is spread by microscopic seeds, or spores (fig. 8, *B*) that are readily carried for miles by the wind. Extremely thick stands of plants are undesirable, as later it is difficult to obtain good coverage with sprays or dusts. In brief, blue mold control will be greatly aided by using narrow beds, sowing at the proper time, and following recommended rates of seeding.

Many growers do not see blue mold until the bed is severely affected. It is then too late to spray or dust. This may be avoided by familiarity with early blue mold symptoms. These vary somewhat, depending on plant size. With plants that have leaves up to the size of a quarter the first evidences of mold are small patches of seedlings with erect leaves. With plants a little older—leaves up to the size of a dollar—the first evidences of mold are yellowed areas. In either case there will be distinctly cupped leaves in the center of each affected area. Some of these cupped leaves will have a whitish, or violet mold growth over the lower surface (fig. 8, *A*). If mold infection is detected in these early stages, treatment can still be started with a fair chance of success. General spread throughout the bed may be expected in about 2 weeks; it is then too late to begin spraying or dusting.

There is no one best method of blue mold control. All recommended methods will prove satisfactory if used properly (fig. 9). It is important to use good materials and equipment, to start treatment early, and not to skip treatments, and to use the full amounts of material recommended.

Gas Treatment

Gas treatment need not begin until blue mold appears. Treatments must start promptly, however, following the very first appearance of

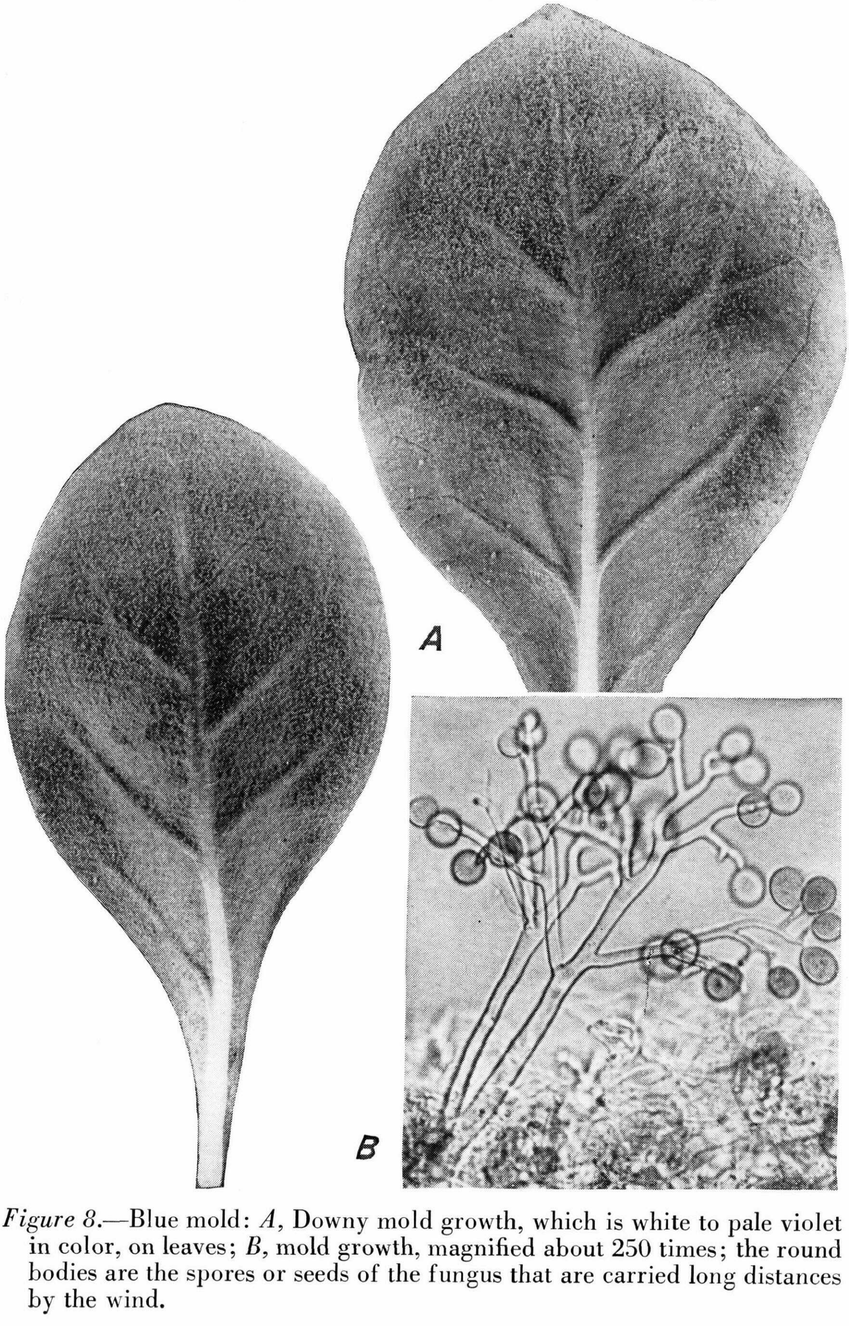


Figure 8.—Blue mold: *A,* Downy mold growth, which is white to pale violet in color, on leaves; *B,* mold growth, magnified about 250 times; the round bodies are the spores or seeds of the fungus that are carried long distances by the wind.

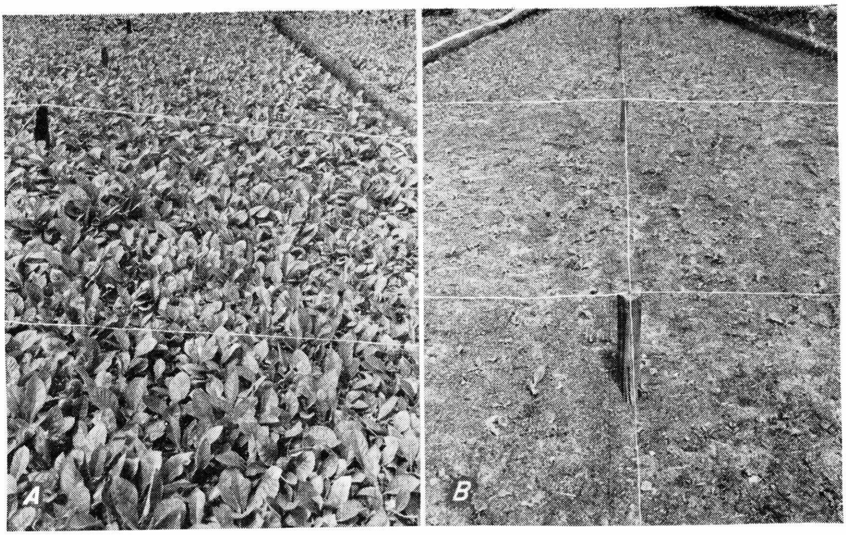


Figure 9.—Effect of control on blue mold: *A*, Sprayed bed, which produced plants at the rate of about 40,000 per 100 square yards; B, unsprayed bed, which produced less than 1,000 plants per 100 square yards.

mold. The bed should be treated for three consecutive nights and thereafter twice each week. Many growers prefer to use the 3-night treatment exclusively, repeating it whenever blue mold is found. The material used is Parabacco or PDB (these are names for paradichlorobenzene); crystals of grade No. 6 are the best size.

To treat a bed, stretch the regular thin cotton cloth (with no holes) tightly, so that it is 8 to 14 inches above the ground. Scatter the crystals over the cover about sundown. Use 3 pounds per 100 square yards ordinarily, but only 2 pounds in warm weather. If the heavier cover used to hold in the vapors is thoroughly wet, 1½ pounds is enough. Never use more than 1½ to 2 pounds on straw beds that have no side walls, or on other beds where the cotton is placed directly on top of the plants. As soon as the crystals are scattered, draw a heavy cover over the bed and fasten it around the sides to hold in the vapors.

A good grade of muslin sheeting or closely woven cotton fertilizer bags sewed together makes a desirable heavy cover. One cover can be used alternately to gas two beds. The heavy cover is usually removed about 8 o'clock in the morning, before the sun gets warm. However, during cool, cloudy weather vaporization of the crystals is slow and covers may remain on the beds much longer. In general, remove covers when the air temperature rises to 70° F.

Spray Treatment

Spraying to control blue mold should start ahead of the disease. In areas where mold is very destructive it is well to begin when the plants are the size of a dime. In other areas spraying should begin when mold is reported in the locality.

The spray materials recommended at present are Fermate-ferbam (ferric dimethyl dithiocarbamate) and Dithane Z–78 or Parzate-zineb

(zinc ethylene bisdithiocarbamate).[10] The rate for the Fermate is 4 pounds per 100 gallons; for the Dithane Z-78 and Parzate, 3 pounds per 100 gallons. The only precaution necessary in mixing is to make sure that the powder is thoroughly wet in a little water before it is added to the bulk of the water. To wet the powder, small amounts can be shaken in a fruit jar. Larger amounts can be stirred in a bucket, water being added gradually. Some agitation is needed during spraying to prevent settling.

The important factors in successful control of blue mold by spraying are: (1) Start in time, (2) apply enough spray and cover the bed uniformly, and (3) spray at regular intervals. The recommended schedule calls for two applications a week, continuing until plants are in the field or until mold has disappeared. Spraying is done through the cotton, providing this is stretched 6 inches or more above the ground (fig. 10). The minimum amount to be applied with small plants is 3 to 3½ gallons per 100 square yards of bed. After plants are half grown or larger, a minimum of 5 to 6 gallons of spray per 100 square yards is needed. If mold-affected spots are observed before the first spray is applied or if infection is observed in a bed that is being sprayed, either use a double-strength mixture for one or two applications, or spray very heavily until the spread of the disease is evidently checked. Then resume the regular applications. During rainy periods when mold is active an extra application is often very helpful.

[10] See footnote 3, p. 8, on the use of trade names.

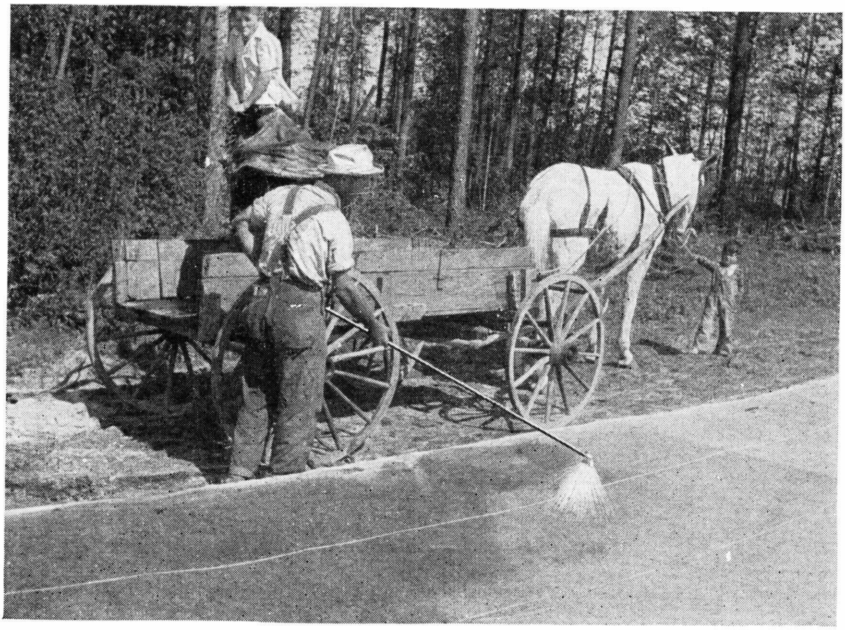


Figure 10.—Spraying for blue mold. A barrel sprayer with at least 25 feet of hose and a rod makes a good outfit. Cotton covering is not removed.

Depending on the season, from 7 to 12 applications will be needed. Any type of sprayer can be used, but wheelbarrow and barrel sprayers are well suited to tobacco-bed work. It is important to have at least 25 feet of hose and a spray rod 6 to 10 feet long.

Dust Treatment

The materials recommended for spraying can also be used for dusting, and the suggestions regarding time to start apply equally to dusting. Recommended formulations are Fermate, 15 percent, and Dithane Z–78 or Parzate, 10 percent. The diluting materials may be talc or Pyrax (pyrophyllite). Fuller's earth or clay diluents should not be used. Lime or land plaster are also undesirable diluents.

Dusts must be applied when the air is quiet. Early morning is usually the best time. Beds 4 yards wide or less can be dusted through the cotton, providing this is stretched at least 6 inches above the ground. The bed shown in figure 10 could be dusted without removing the cotton. Wide beds must have the cotton removed to insure uniform coverage (fig. 11). A good rotary-type duster is most satisfactory.

Small plants require 1½ to 2 pounds of dust per 100 square yards per application. The rate increases as the plants grow; large plants should receive 3 to 3½ pounds per 100 square yards. In case blue mold spots are observed, dust the affected area heavily until active disease development is checked. The regular schedule for dust treatments is twice weekly, but, in any event during periods when blue mold is active, all leaf surfaces exposed must be kept coated with dust. Rain will wash off dust, so applications must be repeated after each rain. Occasionally 3, or even 4, treatments are needed during a single week. The total number of applications required for the season may range from 7 to 15.

Figure 11.—Dusting for blue mold. Large beds with the cotton resting directly on the plants must have the cotton laid back for effective dusting. A rotary-type duster is most satisfactory.

892178°—50——4

ANTHRACNOSE

Anthracnose [11] produces numerous light-colored spots on the leaves (fig. 12). The lower surface of the midrib and the lateral veins have red-brown, elongate lesions. Severely affected plants are usually grouped in definite areas, 3 to 4 feet in diameter. The leaves of such plants are much puckered and the plants are stunted (fig. 13).

[11] Caused by *Colletotrichum* sp.

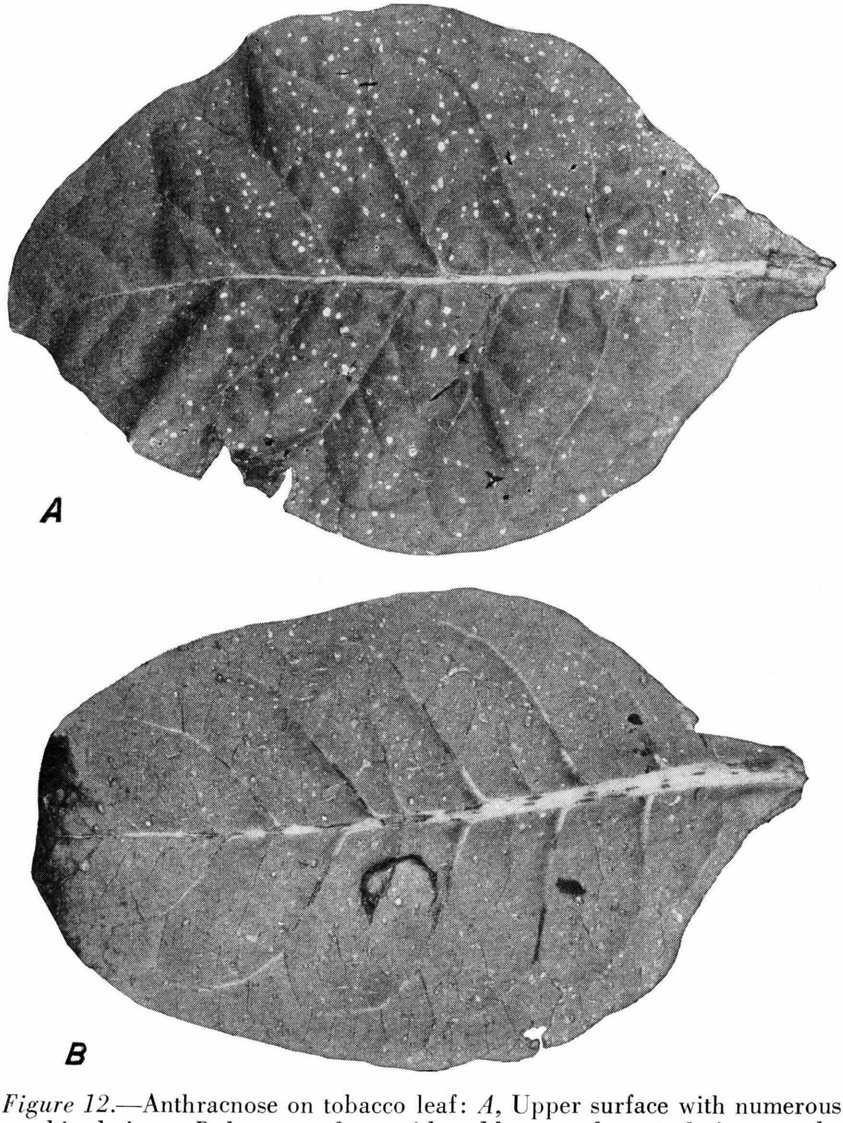


Figure 12.—Anthracnose on tobacco leaf: *A*, Upper surface with numerous white lesions; *B*, lower surface, with red-brown, elongate lesions on the midrib and the lateral veins.

Figure 13.—Anthracnose-infected plants are much dwarfed, and the leaves are puckered. Plants in the right foreground were most severely diseased.

Anthracnose is a common disease in plant beds in Maryland, and it is found occasionally in other areas. It has not usually caused trouble in the field. The spray or dust treatments recommended for blue mold have regularly given excellent control of anthracnose.

GREEN SCUM

About the time that plants are coming up, some beds develop a moist, green growth over the entire soil surface. This scum is made up of minute plants (algae). The growth of these organisms is favored by excessive quantities of dried blood, cottonseed meal, or other organic materials in the fertilizer. Two applications of bordeaux mixture, as described under wildfire control, will destroy the green scum without injury to the seedlings.

WILDFIRE AND BLACKFIRE

Wildfire [12] is easily recognized in the plant bed. The infection is never uniformly distributed over the bed. Rather, there are spots from 1 to 2 yards in diameter with the most severely diseased plants in the middle, and perhaps in the very center a small area where all plants have been destroyed. Individual lesions on the leaves are yellow and usually have a small white area of dead tissue in the center. Blackfire [13] (angular leaf spot) is more generally distributed in a bed,

[12] Caused by *Pseudomonas tabaci* (Wolf & Foster) F. L. Stevens.
[13] Caused by *Pseudomonas angulata* (Fromme & Murray) Holland.

and the appearance of the lesions is variable. They may be small, light-colored dead areas that can be mistaken for flea beetle injury, or dark, irregular dead areas.

The occurrence of either wildfire or blackfire in beds is a serious matter, for it means that the plants set out in the field will carry the disease. In the field either disease can cause major crop losses. The object of bed treatments consequently is the complete prevention of any wildfire or blackfire infection. Anything short of complete elimination is of limited value. Preventive treatments (fig. 14) must, of course, be applied in advance of disease occurrence.

The materials to be used are copper sprays—either bordeaux mixture or one of the prepared copper compounds (Copper-A or Tennessee Tribasic).[14]

Treatments used successfully in different areas vary somewhat. In Kentucky, bordeaux is recommended. It is prepared as follows:

Dissolve 3 pounds of powdered bluestone (copper sulfate) in 3 to 4 gallons of water.
Mix 4 pounds of hydrated lime in another 3 to 4 gallons of water.
Fill a 50-gallon barrel about three-fourths full, and add the two lots of material, first the lime solution and then the copper, stirring vigorously.
Add enough water to make the full 50 gallons.

This bordeaux is applied with a sprinkling can at the rate of 25 gallons per 100 square yards of bed. It is not necessary to remove the cotton, but care should be taken to wet the framing logs or boards and to get into all corners.

The first application is made immediately after the plants are up; a second application, 10 days later. Weeding immediately ahead of treatment is recommended to prevent infection from soil that is brought to the surface.

In Wisconsin one of the fixed copper compounds is recommended as being more convenient to use than bordeaux mixture. The material is stirred into water at the rate of 1 pound per 10 gallons. It is then applied with a sprinkling can. This material must be kept agitated while it is being applied. The recommended rate is 9 to 18 gallons per 100 square yards. The first treatment is made 1 to 5 days after seed sowing, and applications are then made about once a week until transplanting time.

In Maryland a combined wildfire and blue mold control program has been successful. Because sprayers are needed for blue mold they are also used for the wildfire applications. Materials used are bordeaux mixture 4–6–50 (about one-third stronger than the Kentucky formula), or fixed copper, 8 to 10 pounds per 100 gallons. The first spray is applied as soon as plants can be seen. Cotton covers, logs, and the soil surface are wet thoroughly. This requires 10 to 12 gallons per 100 square yards. A second application of 6 to 8 gallons per 100 square yards is made in a week to 10 days, and usually a third application a week later. Blue mold spraying generally begins 1 or 2 weeks after the last copper spray for wildfire.

---

[14] These and similar preparations contain about 50 percent copper.

Early applications are essential for wildfire and blackfire elimination in the plant bed. The first treatment must be thorough and must be applied as soon as the plants are up. Dusting with copper fungicides has not been as effective as spraying.

Figure 14.—Wildfire control in the plant bed: *A*, Bed that received three applications of bordeaux mixture, starting as soon as the plants were up; *B*, wildfire-infected area in an untreated bed.

LEAF DISEASES IN THE FIELD

WILDFIRE AND BLACKFIRE

Damage caused by wildfire and blackfire in the fields varies greatly in different years and areas. In all major areas, however, there have been years when these leaf spot diseases were extremely destructive. There appear to be periods when these diseases are most prevalent, and such a period may be followed by a number of years when the diseases are entirely absent. Thus, wildfire was destructive in 1948 in the burley areas of Kentucky and Tennessee, but the disease was not observed in the flue-cured area of North Carolina.

Wildfire lesions on field plants are rounded, light-colored, dead areas, with the younger lesions showing the yellow "halo" border typical of the disease in the bed (fig. 15). Blackfire lesions are more irregular, and darker in color (fig. 16). On older leaves and during the later part of the season it is often difficult to distinguish between the two. At present the most effective field control for these leaf spots is elimination of all infection from the plants in the bed. Therefore, in the areas where these diseases are now active the previously described bed treatments with copper fungicides are very important. Infection will live over in field soil at least 1 year, and for this reason rotation is helpful.

Fertilization and topping practices affect the susceptibility of the plants to the leaf spot diseases. Low topping and high-nitrogen fertilization favor disease damage. Under some conditions low potash increases susceptibility. However, these are practices that must be carefully adjusted to the particular type of tobacco being produced. They are not very effective as leaf-spot-control measures. Crops affected badly by wildfire are usually cut early to save as much as pos-

Figure 15.—Wildfire as it appears in the field: The small lesions usually show the yellow "halo"; the large, dark lesions show little or no halo.

sible. Work on the development of wildfire-resistant varieties is well advanced, and the introduction of such types may be expected in the near future.

BROWN SPOT

As tobacco matures, the leaves become susceptible to infection by several leaf diseases, one of which is brown spot.[15] The lesions are rather large, tend to be circular, and are frequently marked by concentric rings (fig. 17). The tip leaves of flue-cured tobacco are commonly affected, and in western North Carolina and Virginia when the harvest period is wet, this disease causes serious damage. No control measures are known.

FROGEYE

Frogeye [16] is also most prevalent on leaves that are maturing. The lesions are usually small, one-fourth inch or less in diameter, and the centers are often parchmentlike, with a scattering of minute, black dots (fig. 18). Frogeye is common throughout the flue-cured and burley areas. Buyers do not object to a moderate amount of frogeye, because the lesions are usually small and their presence is accepted as a good indication that the tobacco is ripe. No control measures are known.

---

[15] Caused by *Alternaria longipes* (Ell. & Ev.) Mason.
[16] Caused by *Cercospora nicotianae* Ell. & Ev.

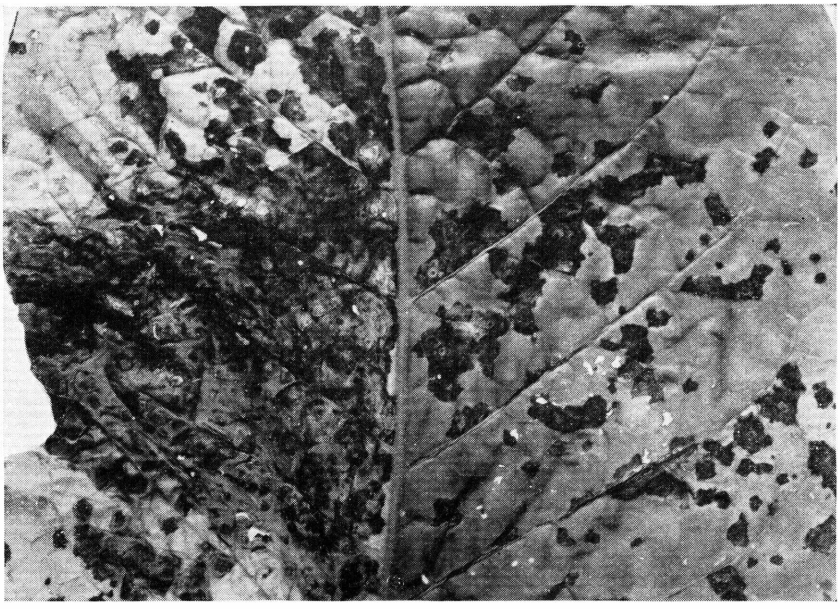


Figure 16.—Blackfire: Distinctive small, angular dark lesions (right); large dead areas (left) resembling same stages of wildfire.

VIRUS DISEASES

In many tobacco-producing areas—particularly in the Tropics—virus diseases are very destructive. A number are present in the United States. The list includes common mosaic, cucumber mosaic, ring spot, etch, vein banding, and streak. Leaf curl and spotted wilt

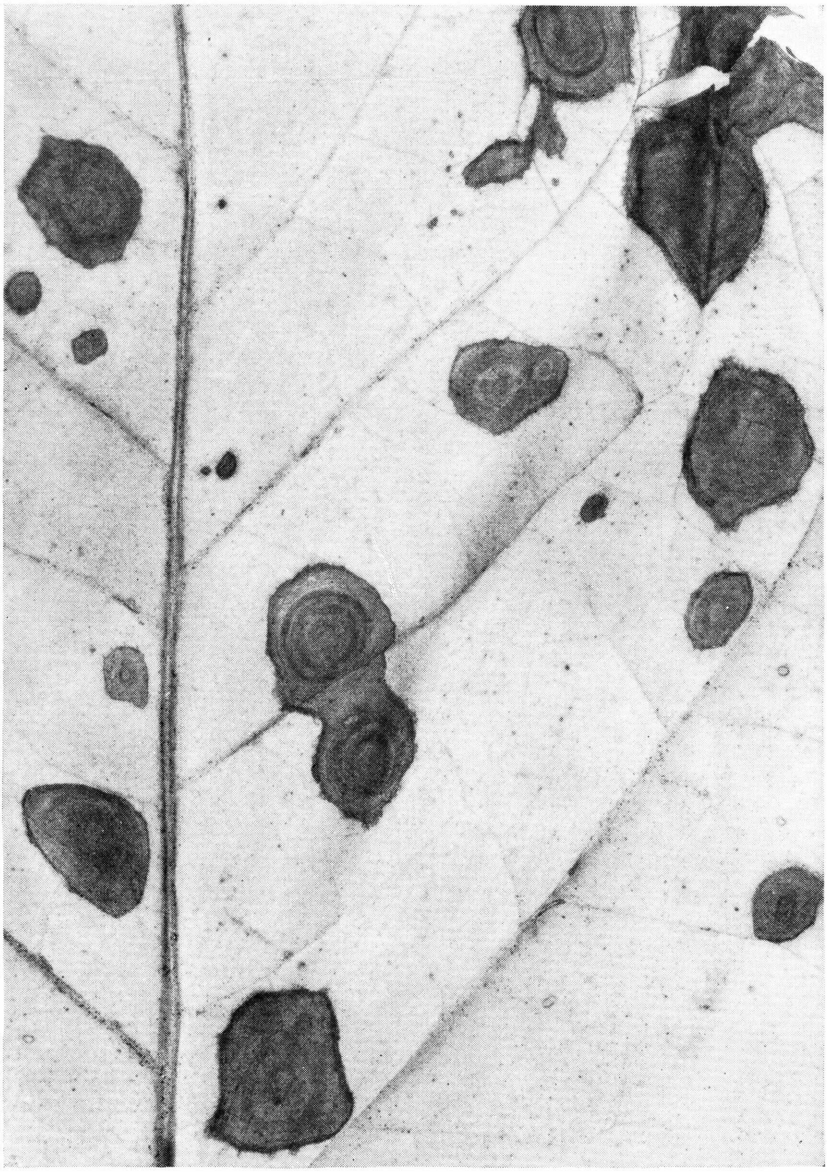


Figure 17.—Brown spot: Dark-brown, rounded lesions, often with concentric markings.

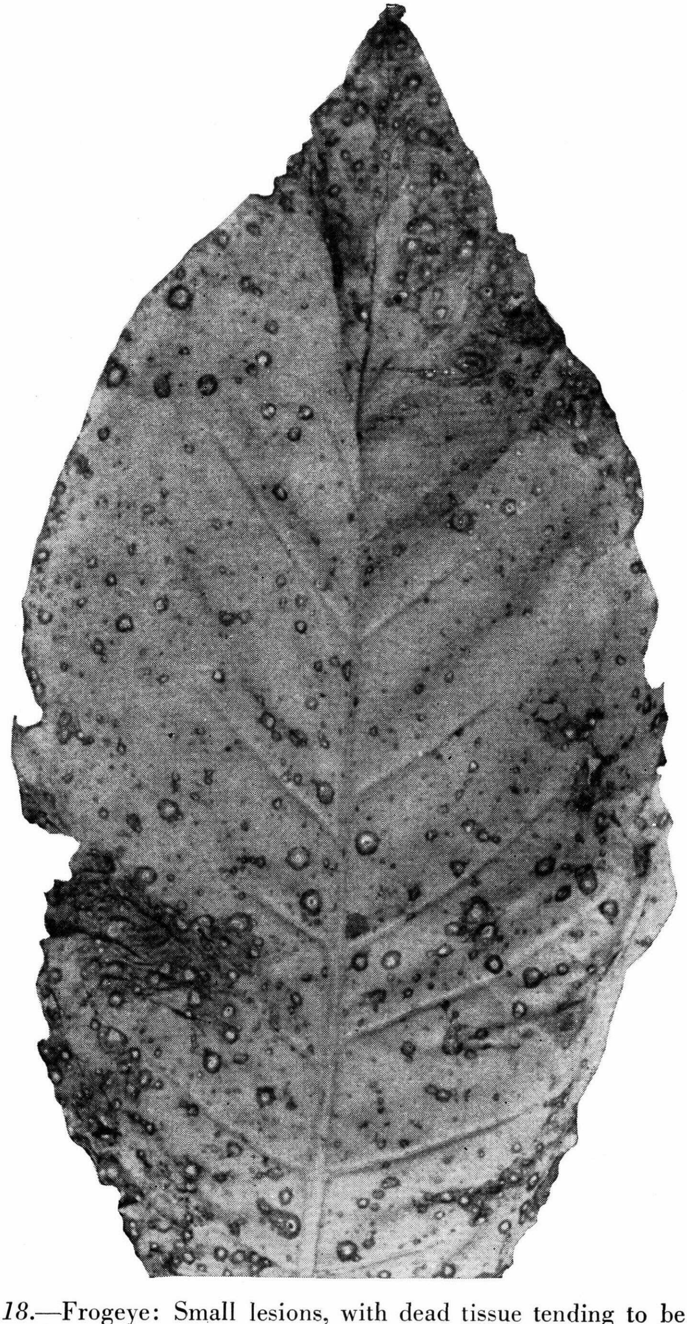


Figure 18.—Frogeye: Small lesions, with dead tissue tending to be paper white and small black dots in the centers of many spots.

892178°—50——5

are serious problems abroad, but have not been observed on tobacco here. This group of diseases constitutes a distinct threat.

In general, the United States tobacco crop at present suffers less from virus diseases than tobacco produced in most other countries. It would be prudent to be on the alert for virus outbreaks and to pay particular attention also to outbreaks of aphids, thrips, or white fly, insects which are responsible for the spread of some of the most serious tobacco-virus diseases.

MOSAIC

Mosaic is well known to most tobacco growers under a variety of local names, such as calico, black french, and mongrel. The characteristic symptom is leaf mottling with yellow-green and dark-green areas intermingled. In addition to the mosaic pattern, younger leaves are frequently blistered and malformed (fig. 19). Plants that contract the disease in midsummer often show mottling only in the tip leaves, and one to three nonmottled center leaves develop large dead areas. This type of injury is called "mosaic burn" (fig. 20). It is an indirect result of mosaic infection.

Mosaic is at present common in all tobacco areas except Georgia, Florida, and South Carolina. It is a very important disease in Maryland, central Tennessee, Kentucky, and Wisconsin. In Pennsylvania, where the tobacco remains in the field for 3 to 4 weeks after topping, as well as in some other areas, the leaves of mosaic plants may show numerous small, roundish dead areas (red rust).

The major damage caused by mosaic is reduced yield and quality. Plants that are infected early—up to 1 month after transplanting—may have their crop value reduced as much as 50 percent. About three-fifths of the loss is in yield reduction; the remainder is in reduction in quality. Mosaic damage decreases as the age of the plants at the time of infection increases. The first objective in a control program consequently is to prevent early infection, not only because this injures the plant most, but also because early infection gives the disease maximum opportunity to spread.

Mosaic is spread by contact. Merely rubbing a diseased plant and then a healthy one will transfer the infection to the healthy plant. The disease infection does not live over in the seed. It survives almost indefinitely in air-dried tobacco, and this is a common source of new infection. Plants in beds are often infected by growers who strip or handle the preceding year's crop and then weed or pull plants. Use of natural leaf chewing tobacco is another way the disease can be introduced into the bed. In either case the contamination is usually spread from the fingers to the plants by rubbing.

Mosaic is rarely seen in the beds because the leaf symptoms do not have time to develop before transplanting, but practically all severe cases of mosaic in the field trace back to bed infection. Late pullings from beds often show heavy field infection; early pullings from the same beds may show very little mosaic. This infection is spread by those who handle infected plants and they then transfer the infection to other plants pulled later. Other possible sources of mosaic infection in plant beds are old stems and leaf trash, which should be kept out of beds, and certain weeds—groundcherry and horsenettle—that are susceptible to mosaic. Plant-bed areas should be kept free of such weeds.

Mosaic infection, if present in the plants, is multiplied at transplanting time. Fields set with 2-man transplanters often show stretches of rows with alternate plants mosaic. This results when 1

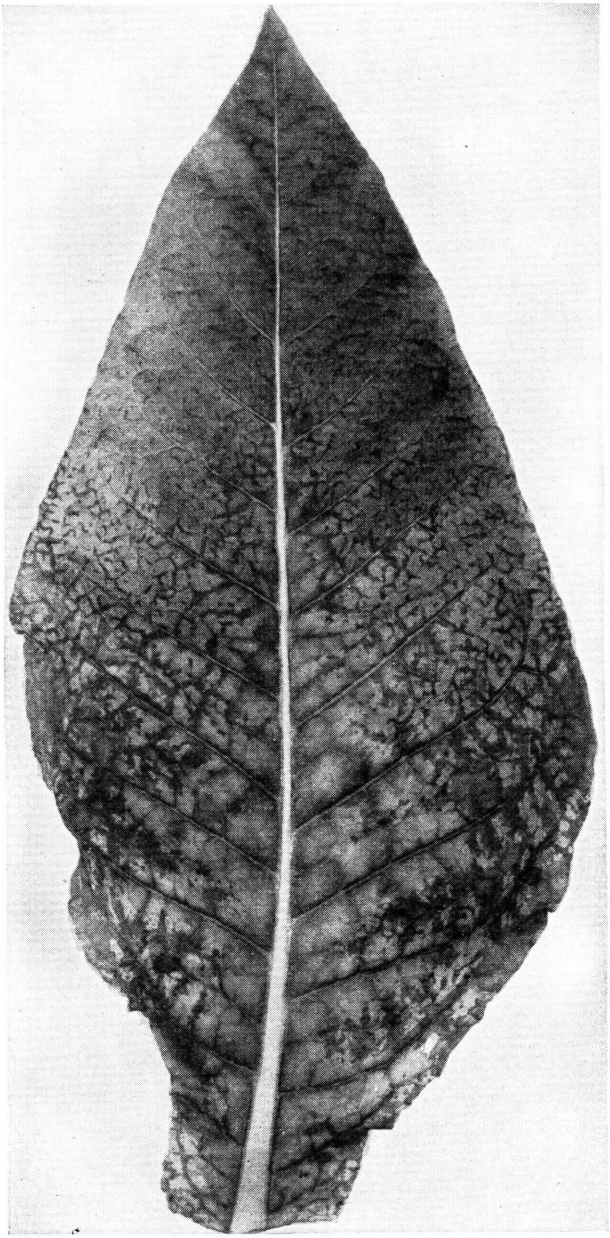


Figure 19.—Mosaic: Yellow and green mottling, most conspicuous on young leaves.

man sets an infected plant and gets enough contamination on his hands to infect 8 or 10 following plants.

In the field it is advisable to inspect the crop carefully just prior to the first cultivation. Infected plants will show mottling of the new leaf growth by that time. Their removal will retard the spread

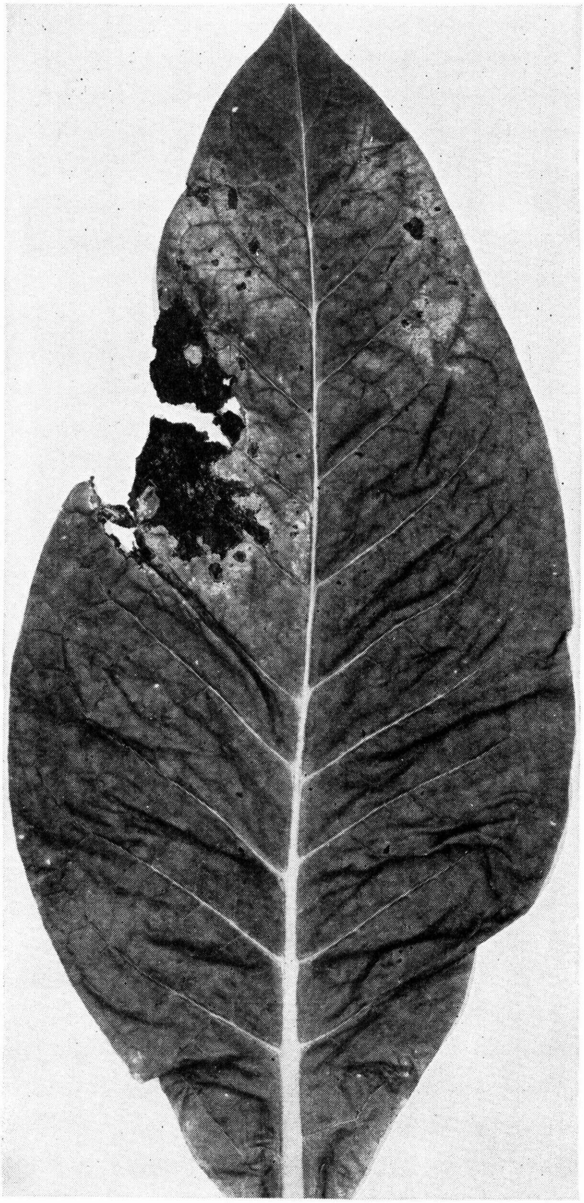


Figure 20.—Mosaic burn: Large dead area and the scattered smaller ones, which are an indirect result of mosaic infection.

of the disease through the field. Field spread results from plant contacts during cultivation, hoeing, and other field operations.

Contamination can be removed from hands and clothes by thoroughly washing them with soap and water. It is sometimes desirable to have a solution that will quickly destroy mosaic infection on hands and tools. This solution can be made with trisodium phosphate (sold as a washing powder), 6 to 8 ounces to 1 gallon of water. The solution is not caustic, but subsequent rinsing in clear water is desirable. Mosaic-resistant varieties are being developed. Some have already been released, and others will be made available soon.

CUCUMBER MOSAIC

Tobacco is readily infected by the virus causing cucumber mosaic, and the symptoms resemble those just described for common tobacco mosaic. It differs from tobacco mosaic in two important respects: It is readily spread by aphids; and the varieties developed that are resistant to tobacco mosaic are readily infected by cucumber mosaic. Occasional tobacco fields have been found that were heavily infected by cucumber mosaic. In general, however, the disease has not been very common.

RING SPOT

Ring spot is easily recognized by the concentric line patterns on the leaves (fig. 21). Frequently these are circular, and again they may parallel the veins. Often leaves on one side of a plant may show the symptoms. Plants affected early in the season usually produce leaves later that are free of symptoms. The virus causing tobacco ring spot can infect many cultivated plants and native weeds. Tobacco crops that follow clovers, lespedeza, and alfalfa are particularly likely to show ring spot infection. The disease occurs in all areas, and it is quite common in Virginia and North Carolina. Ring spot infection may be carried in the seed; hence, it is not advisable to save seed from affected plants.

ETCH

Etch symptoms are first chlorotic spots of tip leaves, and later mottling in the leaves lower down. This mottling is somewhat similar to the mottling produced by common mosaic. An easy distinction is that with common mosaic tip leaves are mottled, while with etch they are not. Etch is spread by aphids, and the widespread prevalence of these insects in recent years has been associated with its more frequent occurrence. Etch is able to attack many native weeds and also peppers. The infection is known to be present in most tobacco areas.

VEIN BANDING

This virus disease causes narrow dark-green bands along the veins. The bands often show most distinctly in the lobes at the base of the leaf. On shade-grown tobacco in Florida etch has caused marked growth retardation and the older leaves have shown numerous dead areas. Vein banding is easily spread by aphids. In addition to tobacco, it affects Irish potatoes and a number of common weeds. At present it is a minor disease, but it is occurring more frequently.

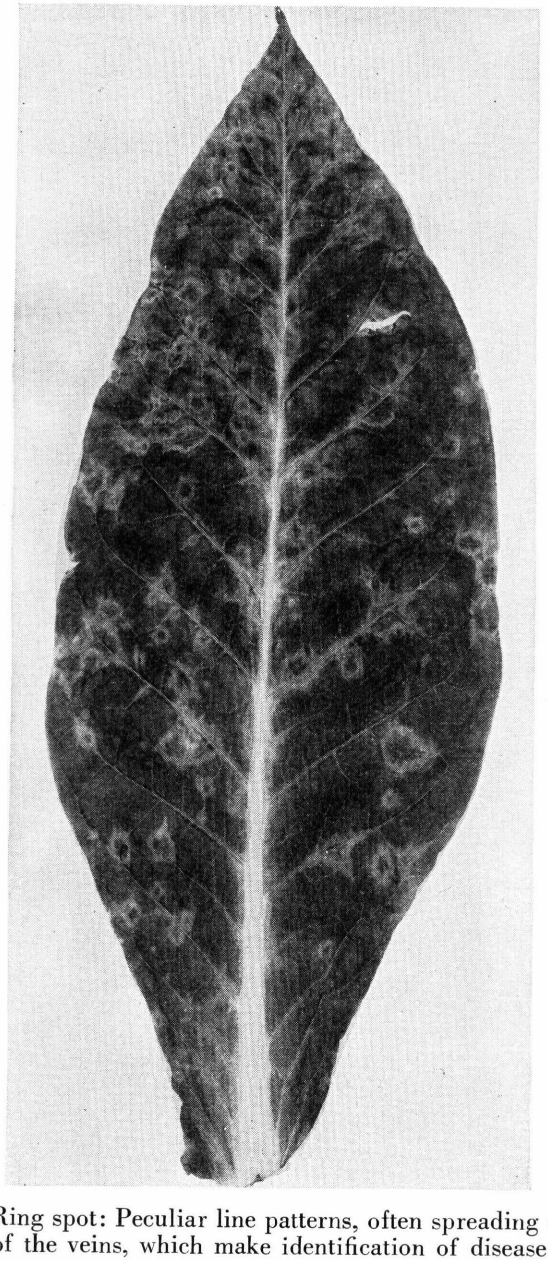


Figure 21.—Ring spot: Peculiar line patterns, often spreading out on either side of the veins, which make identification of disease easy.

STREAK

Streak rarely affects more than occasional plants, but the attack is sudden and the symptoms are severe. Apparently, normal-growing plants develop a necrosis, puckering, and curling of the young leaves. The stalk shows depressed dead areas; the midribs have dead

streaks; and the small veins are darkened. The affected plants appear permanently injured and likely to die. This severe stage soon passes, however, and the plants resume apparently normal growth, with only the original affected leaves misshapen and dwarfed. Streak is fairly common in the burley areas, where its occurrence is associated with sweetclover. It also occurs in Wisconsin and more rarely in other areas.

STALK AND ROOT DISEASES

BLACK SHANK

First identification in the United States of black shank[17] was in Florida in 1924. It immediately became a serious problem in the shade-grown tobacco area. In 1931 it was discovered in the flue-cured area near Winston-Salem, N. C. Spread in North Carolina and Virginia has been rapid in recent years. The disease was found in South Carolina in 1948 and in the burley area of eastern Tennessee in 1949; also on one farm in Maryland that same year. In North Carolina and Virginia the disease has proved very destructive; however, it is not equally destructive in all areas. Thus, it is known to have occurred in the Georgia flue-cured area at least three times during recent years, and each time it has disappeared. It has been present in the dark fire-cured area of Tennessee and Kentucky since 1935, and has increased only gradually. Nevertheless, this disease is feared and with good reason, so that growers who do not now have it on their farms should take every precaution to avoid introducing it.

[17] Caused by *Phytophthora parasitica* (Dast.) var. *nicotianae* (Breda de Haan) Tucker.

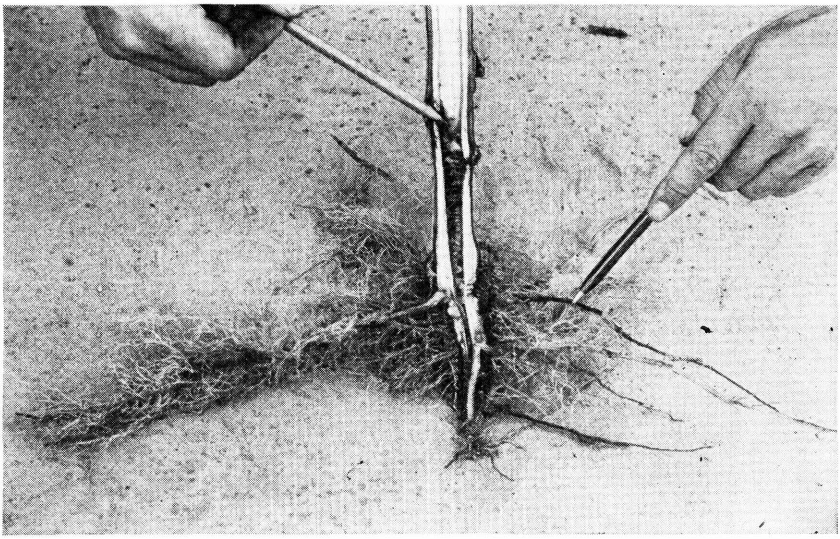


Figure 22.—Black shank: Blackened dead roots, with decay extending up the pith into the base of the stem.

The disease almost always makes its first appearance in a low area. Usually about midsummer a few plants begin to wilt. If one of these plants, in the early stages of the disease, is pulled and the roots examined, one or more of the larger lateral roots will be found to be blackened and dead (fig. 22). The stalk at this early stage will be free from decay or discoloration. As the disease progresses the entire root system and the base of the stalk will decay and die.

Black shank infection will survive in the soil; it is usually spread by means of contaminated soil, water, or plants. The soil is often carried by road-working machines, on the wheels of trucks, or on farm implements. The danger of spreading infection with soil is much greater when the soil is wet. Water easily becomes contaminated with black shank, especially when small streams and ponds receive drainage from diseased fields. If the water from such sources is used in beds or for transplanting, the disease is likely to be introduced. Finally, many farmers bring black shank to their farms for the first time on plants; hence, it is a most important protection for the grower to produce his own plants.

Frequently a grower discovers black shank when it is confined to one part of a single field. Prompt action then can do much to delay its spread. The first step is to avoid spreading the disease on cultivators or equipment to other fields. The affected field should be seeded down to grass or a crop that requires no cultivating as soon as possible. The disease can persist in the soil in absence of tobacco for at least 5 or 6 years. These measures will probably not eliminate the disease, but they greatly delay its spread.

Once the disease is scattered over a farm the only solution is the use of black-shank-resistant varieties. Flue-cured varieties are now available. Oxford 1 stands up very well if grown in a 2- or 3-year rotation (fig. 23). If tobacco is grown continuously, the level of black-shank-

Figure 23.—Black shank resistance: Local susceptible variety, called Special (center) with black-shank-resistant Oxford 1 on either side.

soil infestation can be raised to such a degree that Oxford 1 resistance is inadequate. Some of the new Vesta black-shank-resistant flue-cured types have higher resistance and will give satisfactory crops under the more severe black shank conditions. Dixie Bright 101 is moderately black-shank-resistant and 102 is more highly black-shank-resistant. Both are also resistant to bacterial wilt. In the Florida-Georgia shade-grown areas, R. G. is a black-shank-resistant variety that is being successfully grown continuously on the same land.

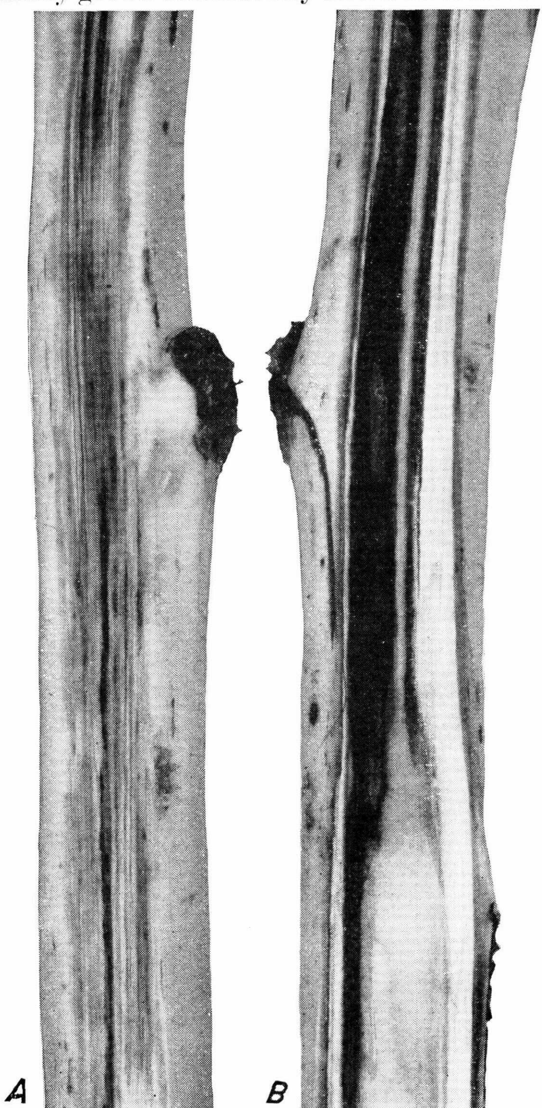


Figure 24.—Bacterial (Granville) wilt: *A*, Thin slice removed from the stem to show the dark streaks in the wood; *B*, stem cut in half to show that decay extends into the pith from the diseased woody tissues.

Bacterial wilt [18] causes plants to wilt, much as black shank does, and the roots to decay. However, if the stem of a diseased plant is sliced lengthwise for a distance of 12 to 18 inches above the soil line, dark-brown, threadlike streaks will be found in the woody part (fig. 24).

The disease was first reported from Granville County, N. C., about 50 years ago. It has since become widespread in that State and in Virginia. It also occurs in South Carolina and Georgia.

Bacterial wilt is a most destructive disease on certain soil types in north-central and eastern North Carolina. Many tobacco farmers in these areas expect an annual loss of 20 to 25 percent of their crop, and much valuable tobacco land has been eliminated from production. Wilt also occurs in many other areas where infection has increased very slowly over a long period of years. Thus, the appearance of wilt in a new locality is not necessarily a serious threat.

Control of wilt by crop rotation is only moderately effective. Many plants besides tobacco are susceptible to wilt. These include some of the common weeds, peanuts, Irish potatoes, tomatoes, eggplant, and pepper. Corn, small grains, grasses, soybeans, and cowpeas can be used effectively in wilt rotations. The rotation should be 3 years or more. For a long time resistance to bacterial wilt was unknown. Recently, however, adequate resistance has been found, and resistant varieties have become the accepted method of control (fig. 25). Oxford 26, the first wilt-resistant variety, will produce normal crops on

[18] Caused by *Pseudomonas solanacearum* E. F. Sm.

Figure 25.—Wilt resistance: Susceptible Gold Dollar (center) and wilt-resistant lines (on either side); one (left) is the original wilt-resistant collection (TI 448).

severely wilt-infected land. Dixie Bright 27, an improved wilt-resistant variety, is now available.

It is not advisable to grow even wilt-resistant types continuously without rotation. Although the wilt resistance is high, these types are not immune. Early in the season, under severe wilt conditions a planting of resistant tobacco may show many affected plants, though most of them will recover later. A short rotation will prevent this and also help to keep in check other diseases that accumulate when tobacco is grown continuously on the same land.

Wilt can also be effectively controlled by applying urea at the rate of 1,000 pounds per acre in the fall and thoroughly mixing it with the

Figure 26.—Fusarium wilt tends to affect one side of the plant.

soil. The nitrogen residue from this treatment prevents the production of good-quality tobacco the following year. Growing corn the first year and tobacco the second, however, has produced satisfactory results.

FUSARIUM WILT

The usual symptoms of fusarium wilt [19] are slow yellowing and dry-

[19] Caused by *Fusarium oxysporum* (Schlecht.) var. *nicotianae* J. Johnson.

Figure 27.—Fusarium wilt: *A*, Outer bark stripped back to show the solid dark-brown color of the wood; *B*, stem split in half to show the diseased woody tissue (left). Note that the pith is not decayed.

ing up of the leaves on one side of the plant (fig. 26). Wilting is not conspicuous. Positive identification can be made by removing the soft outer bark from the affected side of a stem. If the disease is fusarium wilt, the surface of the wood exposed is dark brown (fig. 27).

Fusarium wilt occurs in Georgia, South Carolina, North Carolina, Maryland, Tennessee, and Kentucky. It is a serious problem in the Whiteville-Chadbourne section of North Carolina. In Kentucky it is reported serious with burley on sandy-soil river bottoms, and particularly in the western part of the State along the Mississippi River.

Growers throughout the flue-cured area should avoid growing tobacco and sweetpotatoes on the same land, because the organism causing wilt on flue-cured tobacco is a strain of the same fungus that causes wilt of sweetpotatoes. For the grower who already has a fusarium wilt problem the remedy is crop rotation and use of resistant varieties.

Strains of burley tobacco that are resistant are available. Oxford 26 is quite resistant, and other flue-cured resistant types are in process of development. In Maryland the disease is usually observed when one of the broadleaved strains is used. The Robinson strain of medium broadleaf is quite resistant.

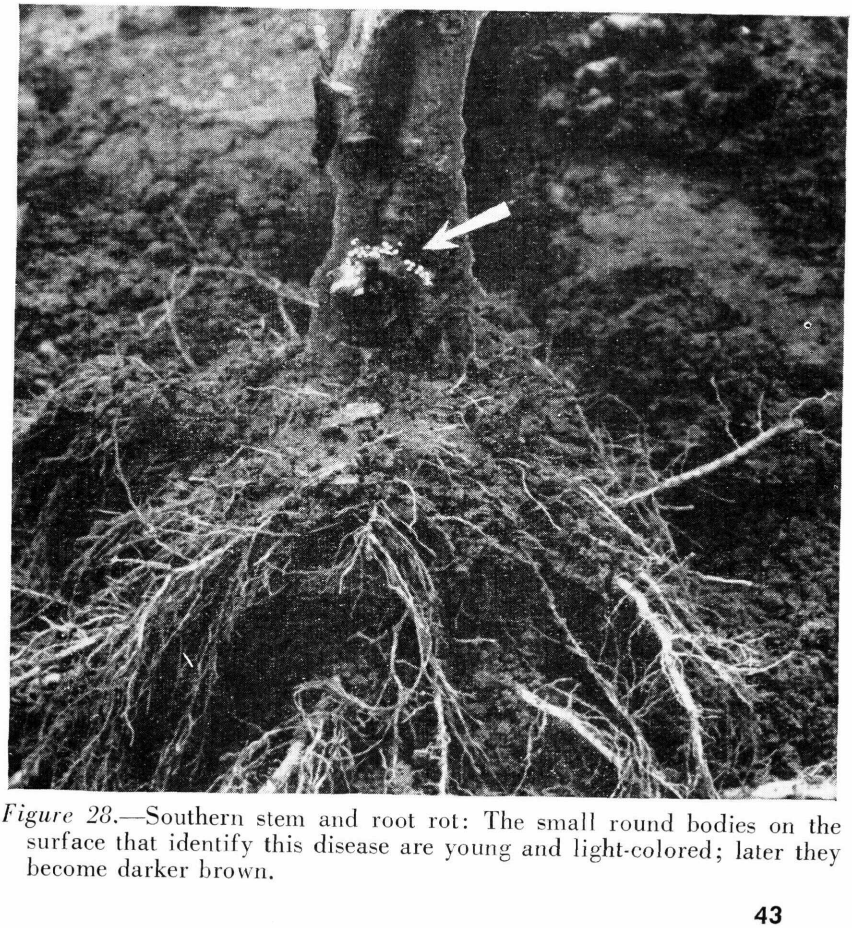


Figure 28.—Southern stem and root rot: The small round bodies on the surface that identify this disease are young and light-colored; later they become darker brown.

Damage from southern stem and root rot [20] is noticeable toward the end of the season. The affected plants wilt and die suddenly, because of a stalk decay at the ground surface that often extends into the root. Adhering to the decayed stem surface are small, round, amber-colored bodies that serve to identify the disease (fig. 28). Affected plants are scattered and usually do not exceed 5 to 10 percent of the stand. The

[20] Caused by *Sclerotium rolfsii* Sacc.

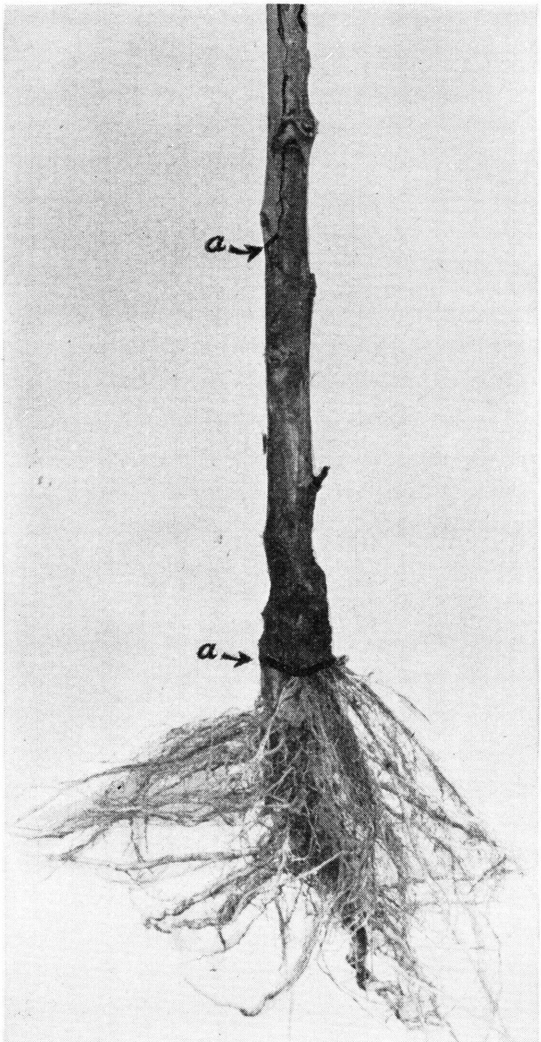


Figure 29.—Sore shin. Limits of the diseased area are outlined in black (*a*). The decay started at the ground level and extended up about 11 inches but did not go down into the roots.

disease is common throughout eastern Virginia, eastern North Carolina, South Carolina, and Georgia. In recent tests soil fumigation for nematodes has also given good control of southern stem and root rot.

SORE SHIN

Sore shin [21] is a common type of stem rot that occurs throughout the flue-cured area and also in other areas. Diseased stalks are smooth and dark brown, and the diseased pith also is brown (fig. 29). The roots do not decay until the entire plant dies. Affected plants are likely to break over. Control measures are not known.

HOLLOW STALK

During the latter part of seasons that are unusually wet, occasional plants may develop a decay [22] that often begins in the pith at the break made in topping. The decay may also start at other stem wounds. The entire pith soon becomes a mass of watery, broken-down tissue that dries up and leaves the stalk hollow. The leaves then wilt and may drop off. The damage from hollow stalk is rarely severe, and no control measures are known.

ROOT KNOT

Root knot [23] is a general problem throughout the Coastal Plain area of Virginia, North Carolina, Georgia, and Florida. Roots of affected plants become swollen and knotted (fig. 30). The most serious dam-

[21] Caused by *Rhizoctonia solani* Kuehn.
[22] Caused by strains of soft-rot bacteria.
[23] Caused by *Meloidogyne* sp.

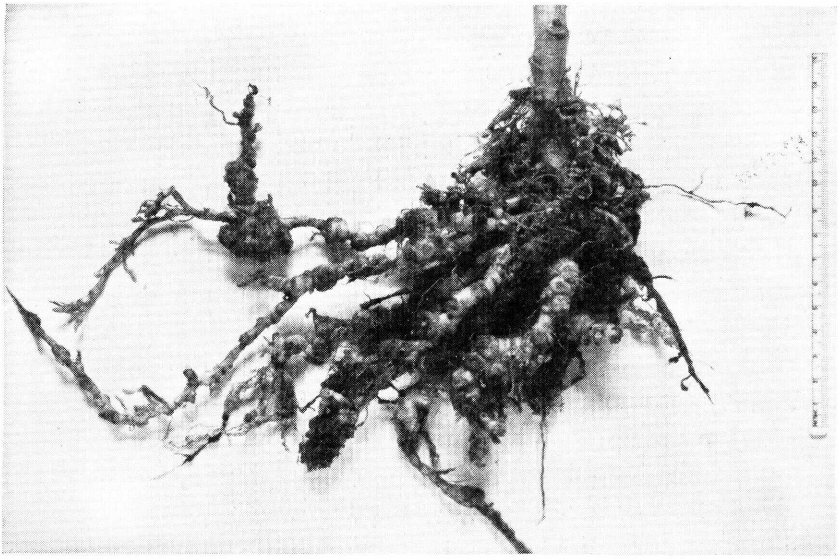


Figure 30.—Root knot: The roots are swollen and knotted; soon they will decay and die.

age occurs on the light sandy soils of the Norfolk series. The disease gradually weakens the plants and retards growth. As the roots decay, the leaves ripen prematurely.

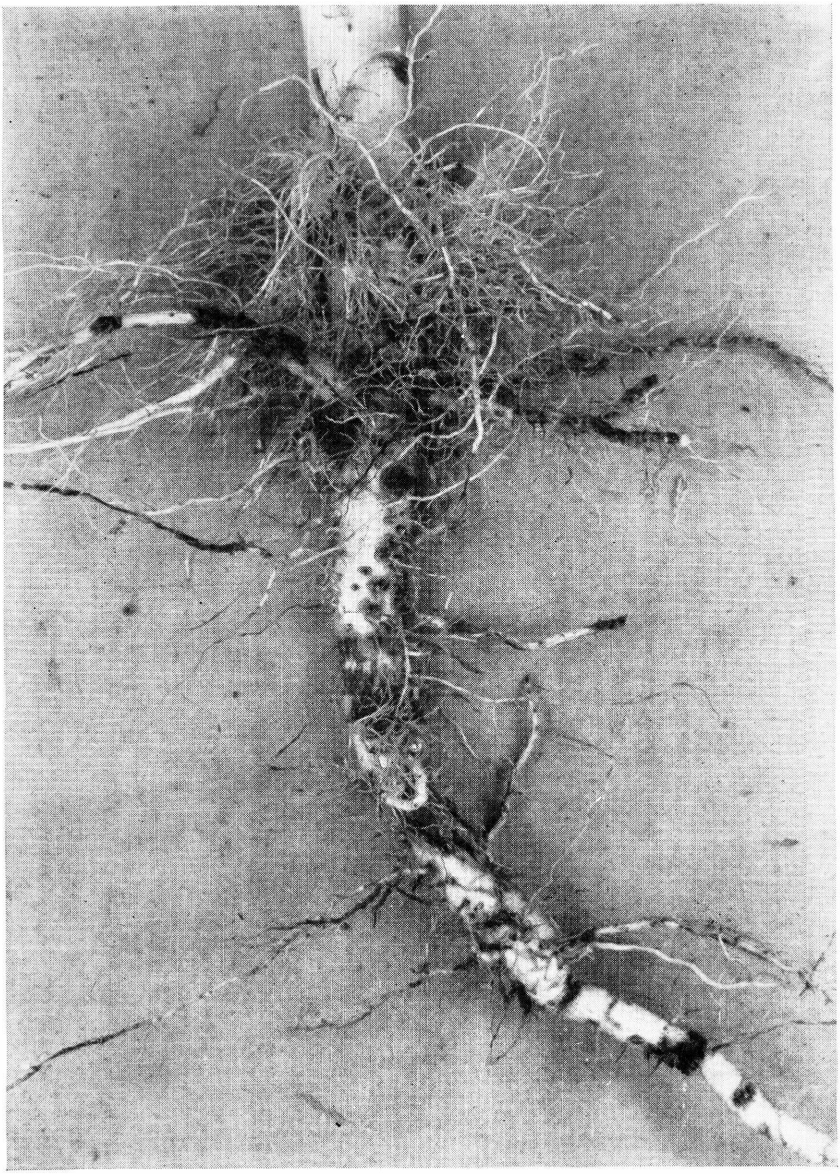


Figure 31.—Nematode root rot. The general color of the diseased root system is red brown. All original feeding roots are destroyed, leaving the taproot and a few larger lateral roots. The newly developed roots near the ground surface would soon be destroyed.

Rotation is the usual method of control.[24] Peanuts and the small grains are especially helpful in root-knot-control rotations. The flue-cured varieties 400 and 401 possess some root knot tolerance, and when grown on infected soil they often outyield varieties such as Gold Dollar and Yellow Mammoth by 300 pounds per acre. Higher degrees of root knot resistance have been found, and the breeding of commercial varieties with this resistance is at present in progress.

Chemical treatments for root knot control are useful in both the plant bed and the field. For plant-bed control the urea-cyanamide treatment (p. 8) is usually most practical and moderately effective. Treatment with chloropicrin and other soil fumigants is highly effective. Good control of root knot in the field is also obtained with the soil-fumigation treatments using dichloropropene and propane and the ethylene dibromide mixtures (p. 15).

NEMATODE ROOT ROT (MEADOW NEMATODE)

Nematode root rot[25] is a common and serious disease in eastern North Carolina and South Carolina. It also occurs in other flue-cured areas and to some extent in the burley areas. The growth of affected plants is stunted, and the roots develop a red-brown decay (fig. 31) that soon destroys all the fibrous feeding roots. The result is that when diseased plants are pulled very little root system remains.

Chemical treatments, as described for root knot, have given fairly good control of nematode root rot. Studies of the susceptibility of other plants to the nematode root rot organism have shown that corn builds up the infection and hence is not a good crop to precede tobacco in areas where this disease is a problem. The same is also true of cotton. The common crabgrass, which often covers the ground in tobacco fields during August and September, is another favored host plant for the nematode root rot organisms.

BROWN ROOT ROT

Brown root rot has long been recognized in the northern areas, particularly Wisconsin and the Connecticut Valley. The symptoms are very similar to those of nematode root rot. Whether the two are identical is not entirely certain. Brown root rot has been closely associated with certain cropping practices. In the regions where it occurs it has been unsafe to plant tobacco after timothy, orchard grass, or soybeans. On the other hand, with continuous tobacco culture, brown root rot quickly disappears. The disease is also uncommon when tobacco is grown after Irish potatoes, bluegrass, or native weeds.

BLACK ROOT ROT

Black root rot, as the name indicates, is a root decay,[26] and the roots are blackened. The disease is most active during cool weather, and the growth of diseased plants is much retarded. It is common in

[24] Control of Flue-Cured Tobacco Root Diseases by Crop Rotation, U. S. Dept. Agr. Farmers' Bul. 1952. 1944.

[25] Caused by *Pratylenchus zeae* Steiner and *P. leiocephalus* Steiner.

[26] *Thielaviopsis basicola* (Berk. & Br.) Ferr.

western North Carolina, Virginia, Tennessee, Kentucky, Pennsylvania, Connecticut, and Wisconsin. Liming encourages the development of the disease, and heavy applications are to be avoided in areas where it is present. In the Connecticut Valley, particularly, the damage has been reduced by keeping the soils quite acid (pH 5.0 to 5.6).

Black root rot control in the field depends on disease-resistant varieties (fig. 32). The more important ones now available are burley varieties Kentucky 16 and 41A and Burley 1; Havana 142, 211, 307, K1, and K2; and flue-cured 400 and Yellow Special. Most of these varieties are moderately susceptible to black root rot in the seedling stage; consequently, control in the plant bed must depend on the use of new locations or soil sterilization.

Very effective control of black root rot in plant beds can be obtained by steaming and by chemical treatments with chloropicrin, urea, or the combination of urea and cyanamide (fig. 33). Steaming, to be effective against black root rot, however, must be done properly. The soil should be dry enough to permit good penetration, and the steaming period should be not less than 20 minutes. The plant-bed burner is effective for the layer of soil treated (3 inches deep). Burning with brush is not usually satisfactory because heat penetration is likely to be uneven.

DISEASE DAMAGE DURING CURING

HOUSE BURN

House burn is a serious problem in all areas where tobacco is air-cured. There are various common names for the trouble—pole rot, pole sweat, shed burn, vein rot, and stem rot. Weather is a major predisposing factor; the disease is favored by prolonged warm, moist periods. The air-cured crop is usually cut, beginning with the middle of August, and house burn weather is most likely to occur between

Figure 32.—Black root rot resistance: Judy's Pride, a susceptible burley (center), with root-rot-resistant burley lines on either side.

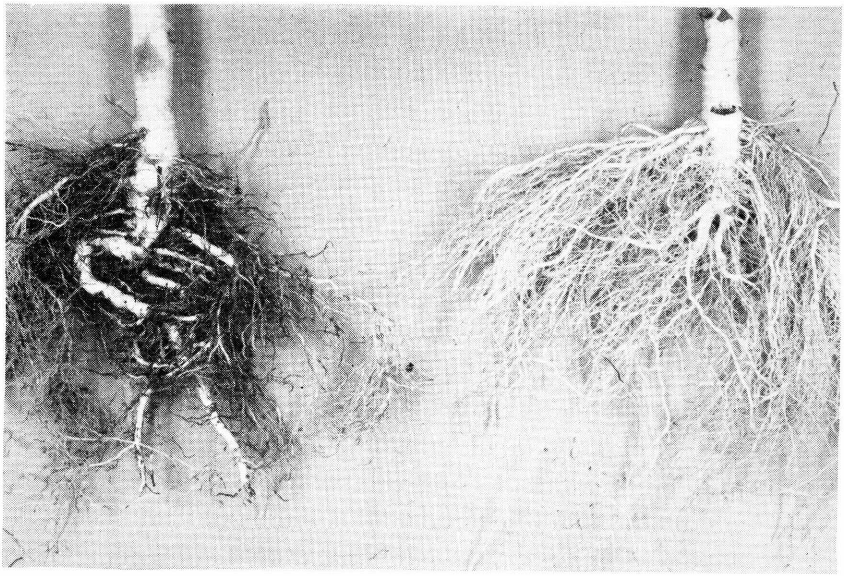


Figure 33.—Black-root-rot control by soil treatment: *A,* Black-root-rot-infected plant from untreated soil; *B,* healthy plant from the same soil treated 2 months earlier with 1 pound of urea per square yard of surface.

then and September 1. The stage of curing has an important influence on susceptibility of a crop to house-burn damage. Freshly cut, green tobacco is not susceptible, but as the leaves yellow and tissues begin to die, susceptibility reaches a maximum. The danger of house burn diminishes as leaf drying progresses, but all danger is not eliminated until stems and midribs are completely dry.

House burn is caused by organisms [27] that vary in their ability to invade leaves and cause decay. It appears that some organisms capable of causing decay are always present.

Depending on the duration of the moist warm period, and on the curing stage at which the attack occurs, there may be all degrees of house-burn damage. A short mild attack may merely cause leaves to darken and become lifeless. Again after the leaf blade is dry, and hence safe against damage, the midrib and larger veins may still be moist enough to decay (figs. 34 and 35). With severe conditions, large portions of a crop may be severely damaged or completely destroyed.

The problem of controlling house burn should begin with a study of how it may be prevented. House burn may occur at any temperature above 60° F., but actually there is little danger unless temperatures are above 70°. Regardless of temperature, however, house burn will not occur unless high humidity prevails continuously for more than 24 hours. The danger is not great until humidity reaches 85 to 90 percent. The grower prevents house burn by careful attention to ventilation and hence to the control of humidity. With burley to-

[27] The fungi involved commonly are *Sclerotinia sclerotiorum* (Lib.) DBy., *Botrytis cinerea* Fr., and *Alternaria tenuis* Cda.

Figure 34.—House burn: Cigar-filler tobacco severely decayed and darkened.

bacco—the major air-cured type—it has been shown that the tobacco cures well without danger of house burn at a humidity of 65 to 70 percent. The grower can judge the correct moisture by the fact that at this humidity level cured leaf will be in very low order. At higher and dangerous humidities cured leaf will become soft and limp, and the surface of green leaf will feel moist.

The problem of tobacco-barn ventilation begins with the location and construction of the barn. Barns in the open on high ground have better ventilation than those on low ground near woods. In some areas the floor of the curing barn is used to stable animals. The extra moisture that results favors house burn; also it is difficult to use fires in such barns. Obviously the barn must have adequate ventilation openings. Most serious house burn damage usually occurs in poorly located, tightly constructed barns that are inadequately ventilated.

Tobacco that is fully ripe when cut cures more quickly than tobacco cut green, and hence is less liable to house burn damage. Since house burn is a problem in moisture control, it is apparent that the more moisture that can be eliminated before the tobacco is hung, the less likelihood will there be of house burn. Therefore, if barn space tends to be short it is most desirable to wilt the cut tobacco thoroughly in the field before it is housed, or it may be desirable to scaffold the tobacco for a week or more before it is moved into the barn. Barn room should be adequate to space the sticks 8 inches apart or more. Closer spacing greatly reduces the rate of moisture loss. Since the space between tiers is fixed, tobacco that is excessively tall laps the tier below.

Spacing is a common problem because of the tendency to seek maximum acre yields, and close spacing increases the house burn problem by hampering ventilation. Some varieties are more subject to house

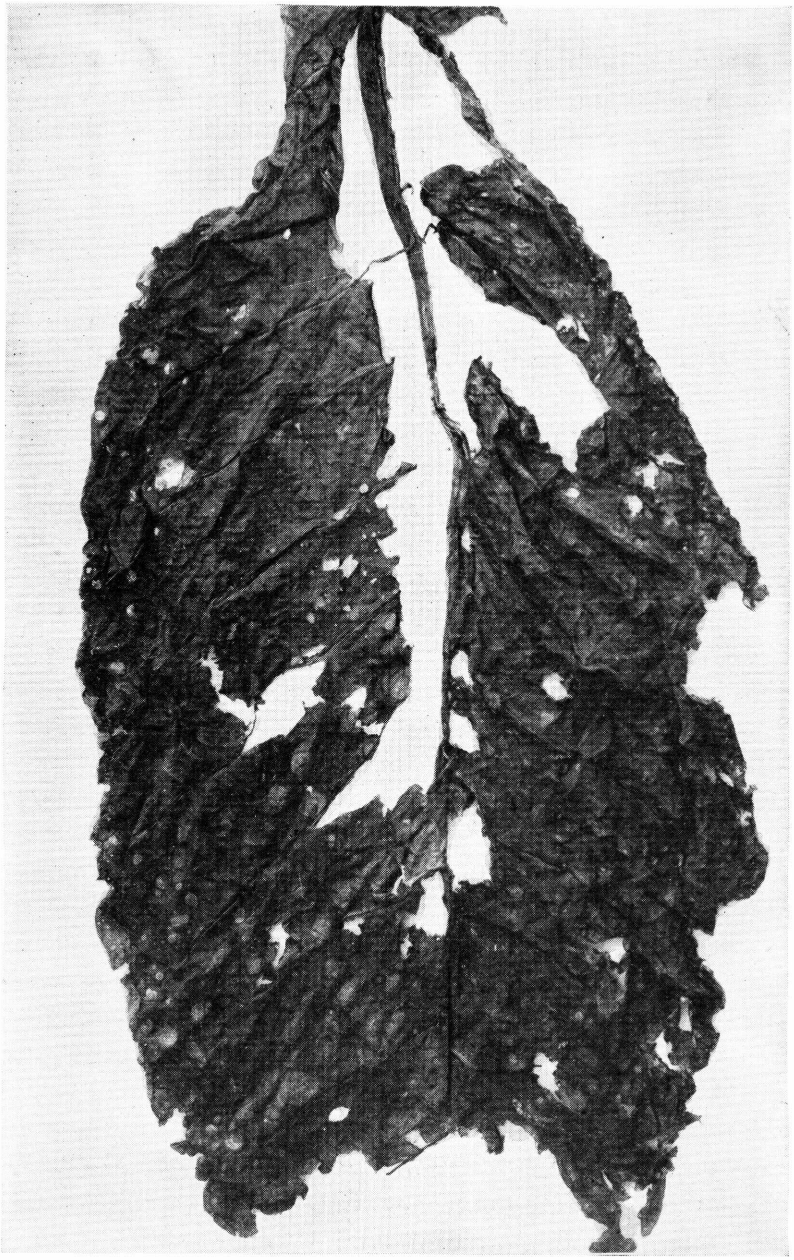


Figure 35.—House burn: Individual leaf showing decay of midrib and adjoining leaf blade.

burn than others. Thus, the wide-leaf strains of Maryland Broadleaf are more likely to house burn than the medium-leaf strains. All these things greatly affect the amount of house burn, and they explain why some tobacco suffers much more from it than others.

Adequate provision for and careful attention to ventilation must take into consideration conditions for curing that will minimize the likelihood of house burn most of the time. Occasionally, however, periods of warm, humid weather make it impossible to dry out the barn. If the cured leaves remain in high order and the green leaves are moist for 24 hours continuously, positive action must be taken at once to reduce humidity. The effective way to do this is by firing. Raising the temperature quickly reduces the humidity. For example, a 20° F. rise in temperature reduces humidity almost 50 percent. If firing is started early, merely raising the temperature inside the barn 5° to 10° above the outside temperature, coupled with judicious ventilation, for a period of 3 to 4 days will be adequate. The length of time to continue firing will depend on the weather and the conditions of the leaves. If leaf tips become dry and stiff while the color is still green or yellow, firing should be stopped, or greatly reduced. It can be resumed later if necessary.

The statement concerning firing assumes that it will be begun in advance of actual house burn. In the event that house burn damage is actually in progress, and the object is to check the spread and development of the trouble, more drastic heating is required. Temperatures should be raised promptly 10° or 15° F. above the outside temperature, but not above 100° F., and held there until the crop is out of danger. Moderate firing that raises the temperature, without rapid drying, might actually increase the house burn damage. Ventilation must be adequate to allow the escape of warm moisture-laden air. Ventilation is always the first choice of the methods of removing moisture. About one-third of the wall area of the barn should be hinged to make adequate ventilation possible.

The usual fuels for firing are lump charcoal, processed charcoal (briquets and charkets), and coke. Coke requires special burners, but it is the cheapest and often the easiest to obtain. Coke burners are spaced about 12 feet apart; charcoal fires are scattered at 6- to 8-foot intervals. It is advisable to arrange the tobacco sticks so that no leaf is closer than 6 feet to a fire.

GREEN SPOT

After tobacco has been air-cured, the leaves sometimes show numerous green-brown spots and the affected tissues are stiff and brittle. This is the result of infections that occur a few days before the tobacco is cut and put into the barn. The organism that causes green spot in the burley area is the one that causes frogeye. In Maryland and Pennsylvania, green spot is often caused by other organisms. The basic cause of green spot in cured leaf is the death of leaf tissues before the green pigments have been eliminated by the normal curing process. Tissues bruised by rough handling during harvesting often cure out a greenish color. Green spot becomes less conspicuous, or even disappears completely, after tobacco has been stored for some time. Buyers discriminate against tobacco that shows green spot.

INJURIES ASSOCIATED WITH WEATHER AND SOIL CONDITIONS

DROWNING

When plants stand in waterlogged soil as much as 48 hours, the roots are asphyxiated and soon decay. The leaves wilt (flop) and the plants die (fig. 36). All degrees of injury may result, from complete destruction of the entire root system to killing of some deeper roots only. Temporary wilting is often associated with partial root destruction.

Tobacco is more susceptible to drowning than any of the other commonly cultivated crops; hence it requires special care with respect to drainage in the bed as well as in the field. Serious drowning damage can frequently be avoided by growing tobacco only on well-drained soils and by prompt action in opening temporary surface drains to carry off excess water.

LIGHTNING

It is helpful to know the symptoms of lightning damage because it is often feared as an outbreak of some new and destructive disease. The area affected in the field is usually circular, but often extends in the direction of the rows. Plants in the center of the affected area may

Figure 36.—Drowning. The water stood in this low area and the plants have "flopped." Most of them will be dead in a few days.

be killed outright, the injury being less and less severe toward the borders. The injured plants are likely to show stem tissue killed at the ground surface, but the roots are not affected. A striking symptom is the drawn and puckered appearance of the leaves. Lower surface examination of such leaves shows that the midrib is shrunken and dark. The pith of affected plants usually dries and separates into disks.

LEAF SCALD

There are several sorts of leaf scald. Sun scald occurs during hot weather after the plant has made rapid growth. Several leaves in the upper-middle part of the plant wilt and dry. Often only parts of leaves are affected and as the damage does not extend to other leaves the loss is slight. Varieties differ in their susceptibility to sun scald, Judy's Pride being one that is slightly susceptible. Another form of leaf scald is associated with the feeding of the stinkbug. Leaf scalds are quite distinct from the leaf burn caused by mosaic and discussed under that disease.

DROUGHT SPOT

During prolonged dry weather tobacco leaves sometimes develop numerous large red-brown spots between the veins (fig. 37). The tissue at the margins of the leaves may die, producing a condition called "rim fire." Chlorine supplied in the fertilizer distinctly increases the resistance of the crop to drought spot. Present fertilizer recommendations for flue-cured tobacco call for a chlorine content of not less than 2 or more than 3 percent. High potash content in the growing leaves also affords protection against drought spot. No chlorine should be used in cigar-tobacco fertilizers, owing to its adverse effect on burn; however, the high nitrogen and high potash in cigar-tobacco fertilizers give some protection against drought spot.

FRENCHING

The early symptom of frenching is loss of green color between the veins of the young tip leaves. With burley these leaves may become almost white. A little later the affected leaves feel thick, are narrowed, and are somewhat drawn in appearance. Frenching development often does not progress beyond these mild symptoms, particularly when it appears late in the season in the tops of plants or on sucker growth. However, when plants develop frenching early in the season, the leaves finally become thick and straplike, with irregularly scalloped margins. Severely affected plants appear bushy (fig. 38).

The tendency to french is definitely related to soil conditions. Certain fields and parts of fields are more likely to show frenching. The occurrence of frenching has been associated with liming, various forms of malnutrition, and poor drainage. In some areas there is also an association with weather conditions. Thus, in most tobacco areas frenching is very common in the late summer after rains, and particularly in low-lying areas. It seems likely that whatever the cause, various nutritional and environmental conditions may either facilitate or retard its development. There is little that can be said regarding control.

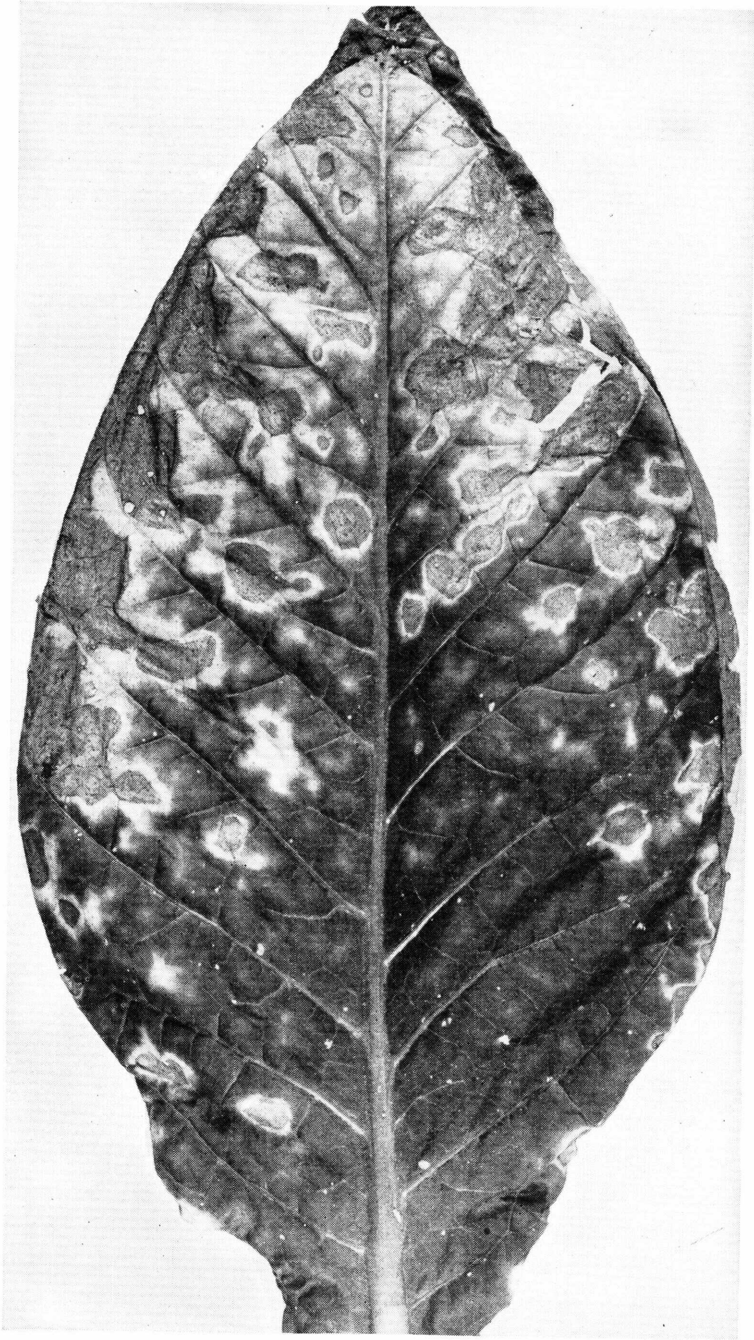


Figure 37.—Drought spot: Large, red-brown spots between the lateral veins.

Figure 38.—Frenching makes leaves narrow and stiff and generally changes the color to a yellow green, except the veins, which remain a darker green.

KEY TO THE IDENTIFICATION OF THE MAJOR TOBACCO DISEASES

PLANT-BED DISEASES

You are likely to observe—	*Most distinctive symptoms*	*Disease*
Plants dying in spots	Stems at the ground surface are withered.	Damping-off.
Growth retarded in some areas.	Plants wilt during the warm part of the day; roots are decayed and black.	Black root rot.
Leaves with large irregular dead areas.	Underleaf surface, before the tissue dies, shows a downy mold growth (fig. 8, *A*).	Blue mold.
Leaves with many small whitish spots.	Veins on the under side have red-brown streaks (fig. 12, *B*).	Anthracnose.
Leaves with rounded yellowish spots.	Younger spots have a dead, light-colored center the size of a pinhead and a broad yellowish border (fig. 14, *B*).	Wildfire.
Leaves with dark irregular spots.	Lesions tend to be angular	Blackfire.

FIELD DISEASES

Retarded top growth and diseased roots.	Lesions on roots localized and black (fig. 33).	Black root rot.
	Lesions on roots red brown (fig. 31)	Nematode root rot.
	Roots swollen and knotted (fig. 30)	Root knot.

You are likely to observe—	Most distinctive symptoms	Disease
Wilting entire plants	Light-brown stalk decay at ground surface; on decayed surface, small round bodies (sclerotia) (fig. 28); affected plants scattered over field.	Southern stem and root rot.
	Dark-brown stalk decay, beginning at ground surface and extending up 12 to 24 inches (fig. 29); no sclerotia; affected plants scattered over the field.	Sore shin.
	Decay begins in root; later all roots and base of stem blacken and die; diseased plants concentrated in definite field areas (fig. 22).	Black shank.
	Disease development same as with black shank; in addition, dark streaks extend up through stem wood (fig. 24).	Bacterial wilt.
Plants that wilt on one side.	Soft bark on affected side removed; solid brown layer on surface of the wood (fig. 27).	Fusarium wilt.
Leaf spots	Younger spots have a small dead center and a wide yellow border (fig. 15).	Wildfire.
	Lesions are irregular, angular, and dark-colored (fig. 16).	Blackfire.
	Spots are rounded, red brown, and often have concentric markings (fig. 17).	Brown spot.
	Spots are irregular; many are paper white with dark dots in the center (fig. 18).	Frogeye.
Leaf malformation and mottling.	Green and yellow mottling that is most conspicuous on young leaves (fig. 19).	Mosaic.
	Older leaves mottled; younger leaves showing only chlorotic spots.	Etch.
	Dark-green borders along veins of older leaves.	Vein banding.
	White dead areas form concentric rings or lines that follow the veins; later leaves show no symptoms (fig. 21).	Ring spot.
	Young leaves suddenly become necrotic and crumpled in appearance; later leaves show no symptoms.	Streak.
	Young leaves are chlorotic; older leaves become thick and straplike (fig. 38).	Frenching.

MALNUTRITIONAL DISEASES

The tobacco plant, to grow normally, requires the following elements from the soil or supplied in fertilizer form: Nitrogen, phosphorus, potassium, calcium, magnesium, sulfur, boron, manganese, iron, copper, and zinc. Iron, copper, and zinc have not been found to be in short supply under field conditions.

The plant shows decreased growth when the supply of any of these elements is deficient. Characteristic symptoms, as a rule, serve to identify accurately the element that is not available to the plant in sufficient quantity. These symptoms can be seen at any stage of

growth from seedling to maturity; therefore, the effects of malnutrition can be noted in either the seedbed or the field. If the deficiency prevails in the earlier stages of growth and continues, the symptoms of retardation naturally will be greater at maturity. As a rule, the most typical symptoms are those that show up first; they are the ones that serve best to distinguish a shortage of one element from that of another. Often more pronounced symptoms can be seen on one side of the plant even on one-half of the leaf than on the other, owing to failure of cross transfer of nutrients. After diagnosis has been made, the practical remedy is usually obvious and easily applied. In most cases, whether in field or seedbed, it consists simply of adding the missing element in suitable form at a suitable time and at the proper rate to the soil.

NITROGEN DEFICIENCY

The growing tobacco plant may show nitrogen deficiency at any stage from the seedling to maturity. The shortage of nitrogen first becomes apparent as the intensity of the normal green color decreases in the growing plants. Associated with this loss of color is a stopping or slowing down of the growth rate. The first change in color is followed by the development of a lemon-yellow to orange-yellow color of the lower leaves. The shade of yellow on the lower leaves appears to be correlated with the intensity of green color prior to the exhaustion of the nitrogen supply, with the deeper shades on the greener plants. This yellowing is followed by a drying up or firing of the yellowed leaves. The number of leaves lost on each plant is determined by the size of the plant and the acuteness of the shortage of nitrogen under the conditions.

A deficiency of nitrogen is shown in figure 39, *B*. In nitrogen deficiency, the upper leaves on the plant assume an erect position, forming an acute angle with the stalk. The younger leaves tend to retain their normal condition, apparently at the expense of nitrogen transported from the older leaves. If the nitrogen shortage becomes acute at the flowering stage, flowering and fruiting is accomplished by means of translocation from the older tissues, although the quantity of seed obtained is reduced. Nitrogen deficiency appears in some manner to produce a plant that has a lower water content than where nitrogen is supplied in liberal amounts. Therefore, nitrogen shortage and reduced water supply sometimes produce much the same symptoms.

PHOSPHORUS DEFICIENCY

Delayed growth is typical of phosphorus deficiency. The tobacco plant grown with a limited supply of phosphorus tends to assume a rosette condition and shows a dark-green color (fig. 39, *C*). The size and shape of the individual leaves are altered, being narrow in proportion to the length. In most instances there appears to be no abnormality other than size, shape, and color of the leaves, but in some instances spots (fig. 40) appear on the lower leaves of the plant.

A slow growth rate and lack of maturity apparently are the dominant effects of lack of phosphorus. The younger leaves tend to form an acute angle (fig. 39, *C*) with the stalk.

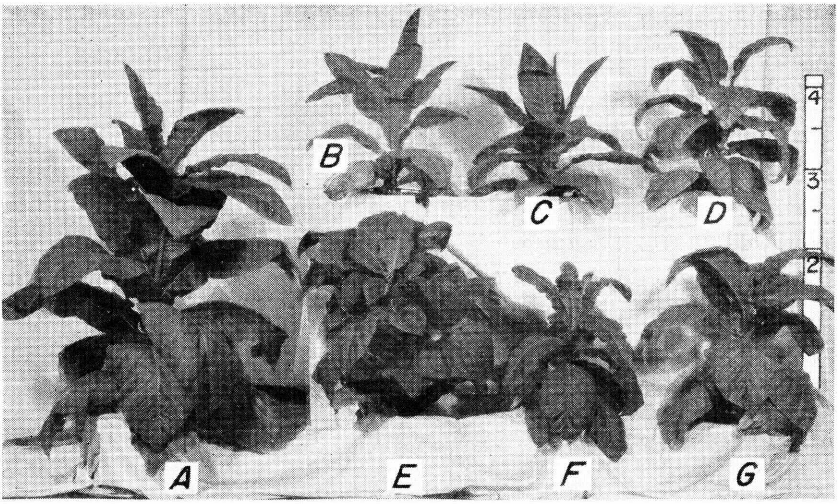


Figure 39.—Effect of shortages of elements on growth of tobacco plants: *A*, Plant given adequate supply of all the elements and therefore showing normal growth; *B*, nitrogen shortage; *C*, phosphorus shortage; *D*, potassium shortage; *E*, boron shortage; *F*, calcium shortage; *G*, magnesium shortage.

POTASSIUM DEFICIENCY

The distinctive effects of potassium deficiency are mottling, generally on the lower leaves (fig. 39, *D*), but if the shortage occurs during later growth the upper leaves may show the first symptoms. Mottling is rapidly followed by necrotic spotting at the leaf tips and margins in the center of the mottled areas. The necrotic areas may later enlarge and coalesce to such an extent that most of the leaf tissues between the veins are involved. These dead areas may fall out, producing a ragged appearance of the leaf (fig. 41). The parts of the leaf that retain their green color are darker than normal, of a bluish-green shade. The necrotic areas, as they enlarge and involve more of the tissue, produce a brown color in drying and give the plant a rusty or brownish color. Even before the chlorosis and necrosis appear, the leaves roll or cup downward toward the lower surface at the tips and margins, doubtless owing to a slowing down of the growth rate in the marginal areas. This condition becomes more pronounced as the chlorosis and the necrosis develop, because the living tissue continues to grow around the chlorotic and dead areas.

Potassium shortage is more noticeable during dry weather. The younger leaves composing the terminal growth tend to retain their normal appearance, apparently because of translocation of potassium from the older to the newer leaves. There may be some loss of older leaves, but that is not characteristic of this deficiency, as in the case with nitrogen. The age of the plant does not determine the manifestation; it may be observed on young seedlings from the seedbed (fig. 42), as well as on mature plants from the field (fig. 39, *D*).

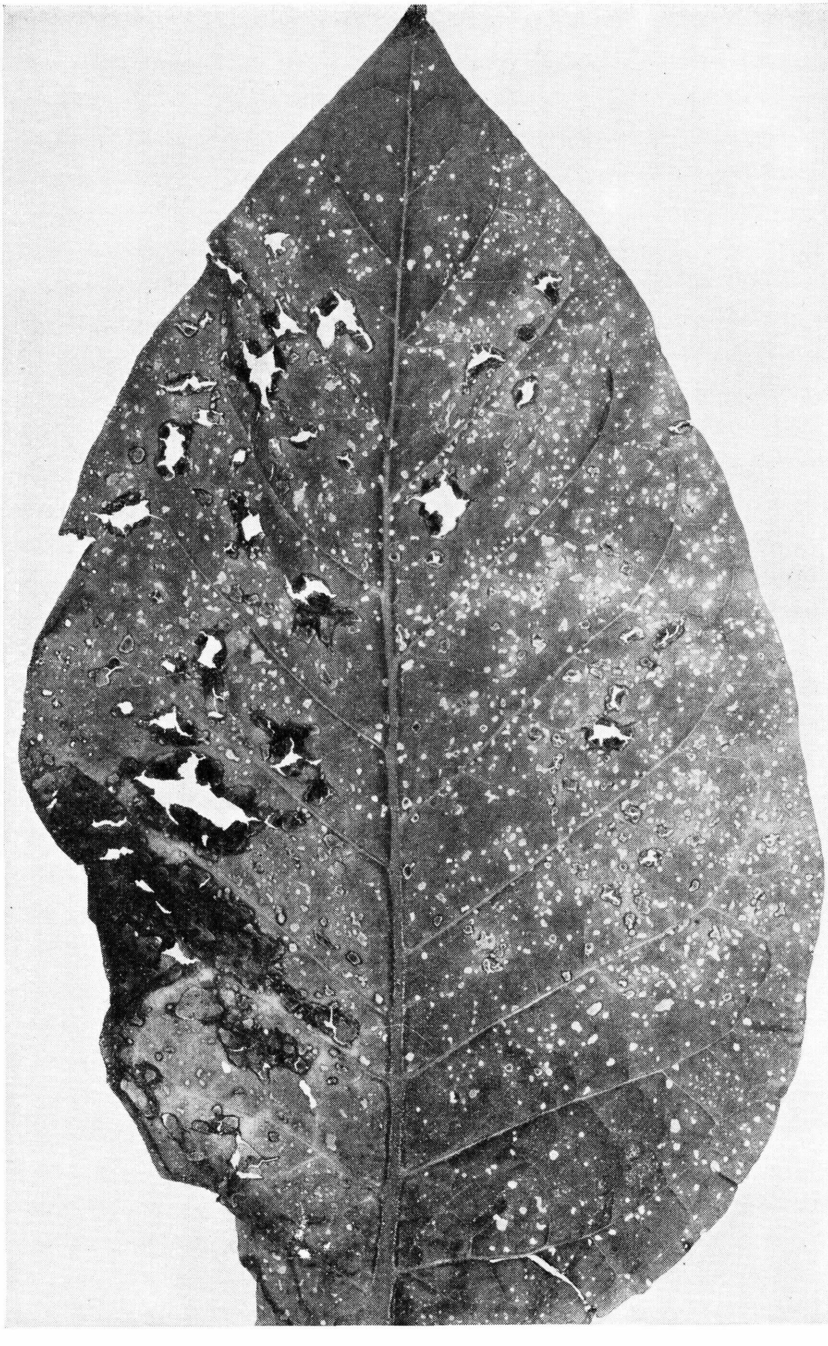


Figure 40.—Tobacco leaf with a leaf spot that sometimes occurs on plants grown with phosphorus shortage.

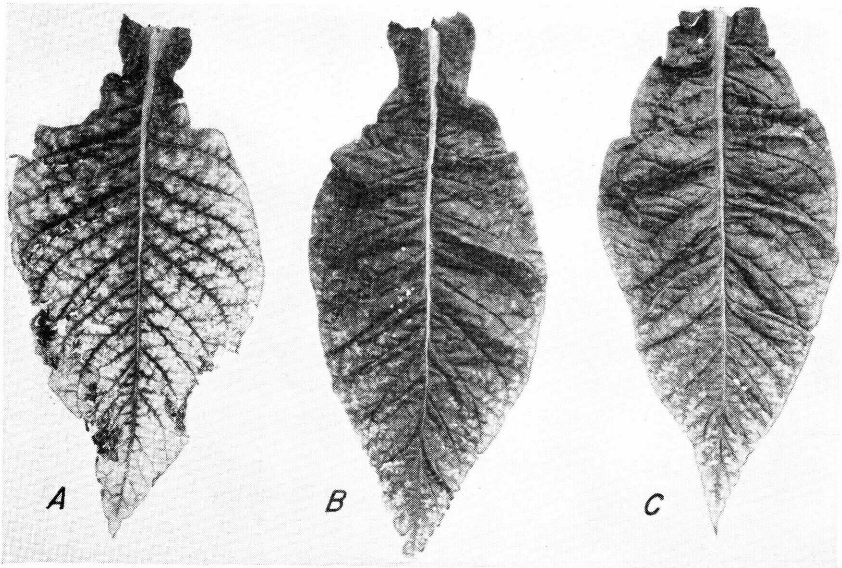


Figure 41.—Tobacco leaves showing, from near the base and upward on the stalk, different stages of (*A*) raggedness, (*B*) necrosis, and (*C*) chlorosis, which are typical of potassium hunger.

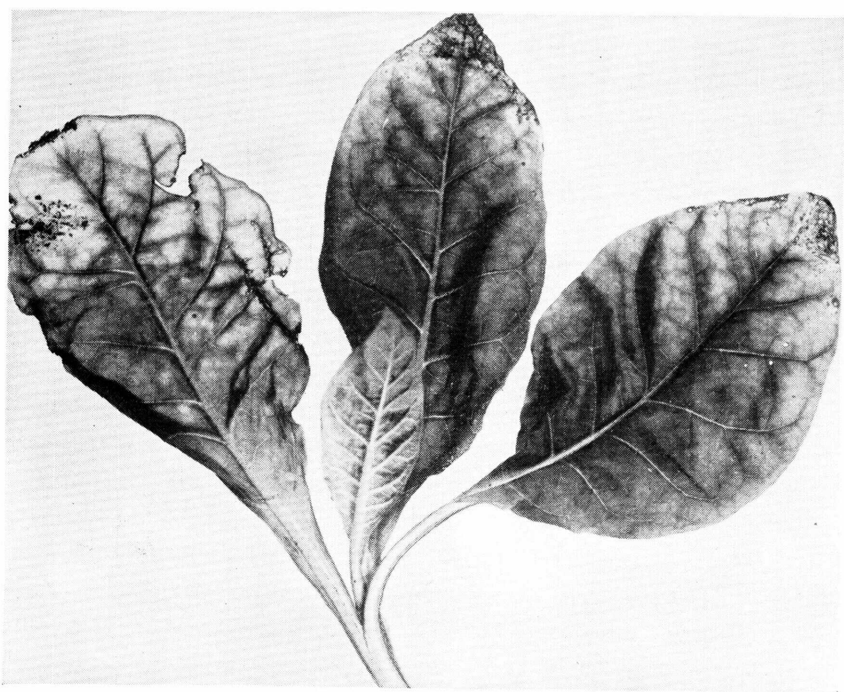


Figure 42.—Tobacco seedling plant, showing typical symptoms of potassium deficiency.

Tests in the field show that liberal supplies of potassium enable the plant to withstand leaf spot diseases caused by bacteria (p. 28). It is possible that the previously described necrosis associated with potassium deficiency allows the organisms causing bacterial leaf spot diseases to enter the leaf tissues and hasten their breakdown. It is well recognized that potassium in some manner aids in maintaining the general vigor of the plant. There appears to be a potassium-nitrogen relation in this connection (p. 28), for with cigar and fire-cured tobaccos given heavy nitrogen applications it is difficult to obtain the protective action of potassium found with Maryland and flue-cured types that are grown with lighter nitrogen fertilization.

MAGNESIUM DEFICIENCY

Magnesium deficiency has been given the common name of "sand drown," because it is most prevalent in deep sandy soils and during seasons of excessive rainfall. As magnesium is part of the chlorophyll molecule, the green color is affected when the magnesium supply is short. The loss of green color commonly progresses definitely. First the lowermost leaves of the plant show a loss of normal color at the tips and margins and between the veins (fig. 39, *G*). The color may vary from pale green to almost white, depending on how extreme the shortage is. The veins (fig. 43) and the tissue close to them tend to retain the normal green long after the rest of the leaf has lost practically all its green color. Even in extreme cases, when the lower leaves are almost white, they rarely dry up or develop dead spots, although the margins often cup upward.

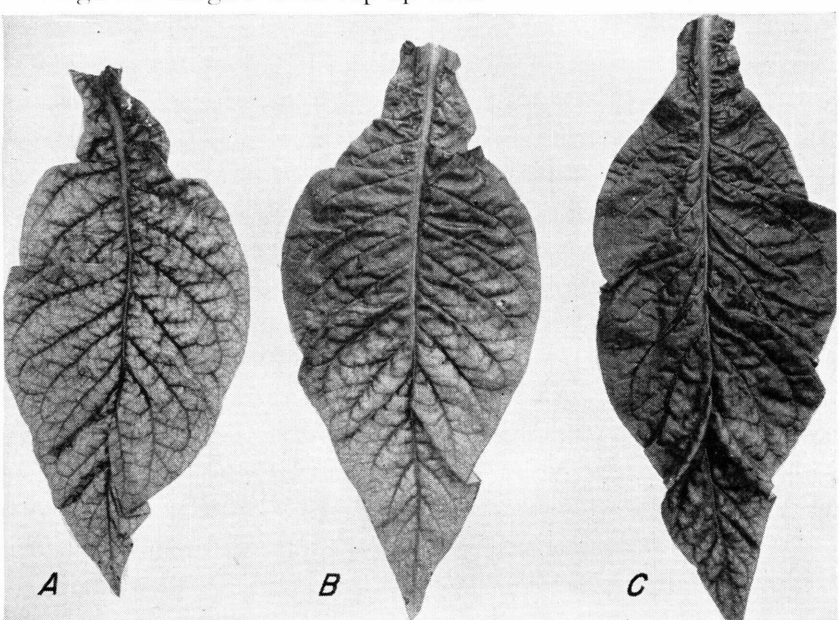


Figure 43.—Tobacco leaves, showing chlorosis distinctive of magnesium shortage. These leaves represent stages of chlorosis which may be found on an individual plant from its base upward.

The loss of color characteristic of magnesium hunger proceeds uniformly, as a rule, from the base of the plant upward. The entire area of the individual leaf and all the leaves of the plant may be involved in extreme cases, though the young leaves of the terminal growth tend to remain normal. The contrast between the pale and normal green color is sharpest in plants with the darker shades of green. It is less striking when the plant is light green because of a low supply of nitrogen or sulfur.

Commonly, the symptoms of magnesium deficiency appear when the plant has attained some size, but they may appear on plants in the seedbed (fig. 44).

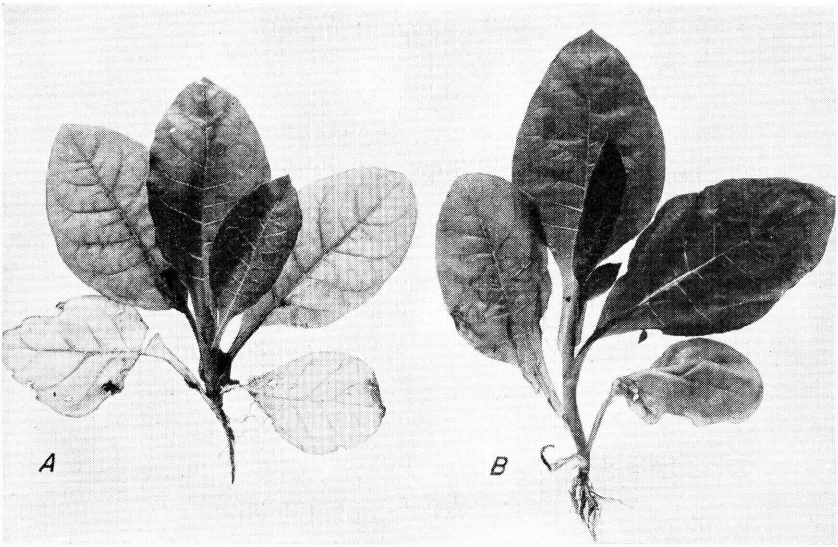


Figure 44.—Tobacco seedlings from a plant bed: *A*, Plant, showing magnesium-deficiency symptoms; *B*, normal plant.

CALCIUM DEFICIENCY

The first symptom of calcium deficiency is the development of a light-green color, followed by a peculiar hooking downward at the tips of the young leaves making up the terminal bud (fig. 45, *A*). This is followed typically by the death of the young leaves that break down first at the tips and margins. If complete breakdown does not occur and growth takes place later, parts of the tips and margins of the affected leaves are missing (fig. 46, *A* to *C*), which gives them a scalloped and distorted appearance. The older leaves (fig. 39, *F*) may be normal in shape.

The plant as a whole is abnormally dark green. In the later stages of extreme calcium shortage, the terminal bud dies. This is equivalent to topping, and it results in a thickening of the older leaves. When lateral shoots or suckers begin to develop in the leaf axils after the death of the terminal bud, their terminal growth in turn goes through the same stages, and the buds die. When calcium deficiency becomes

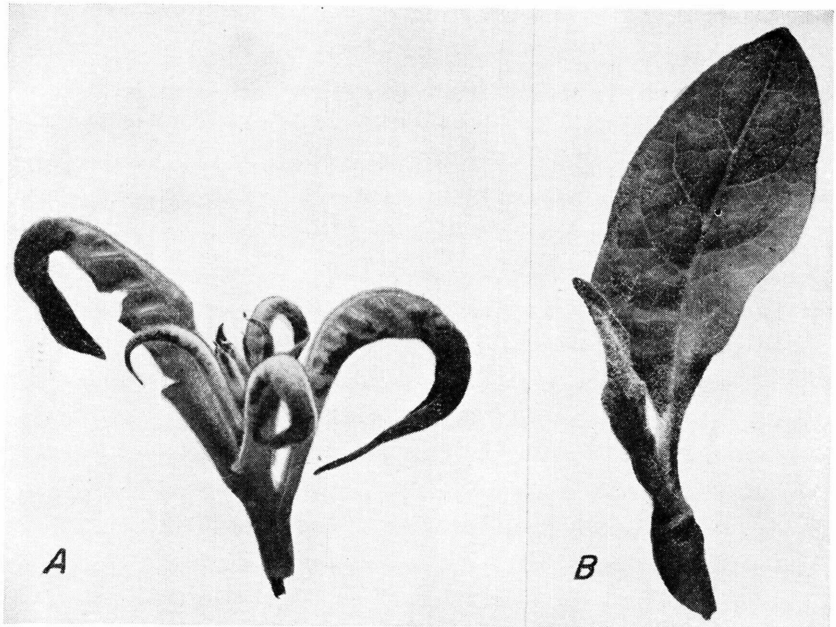


Figure 45.—Terminal growth of tobacco plants as affected by calcium and boron deficiency: *A,* First stage of calcium shortage on young leaves making up the bud; *B,* an early stage of boron deficiency as it affects the young leaves composing the terminal growth.

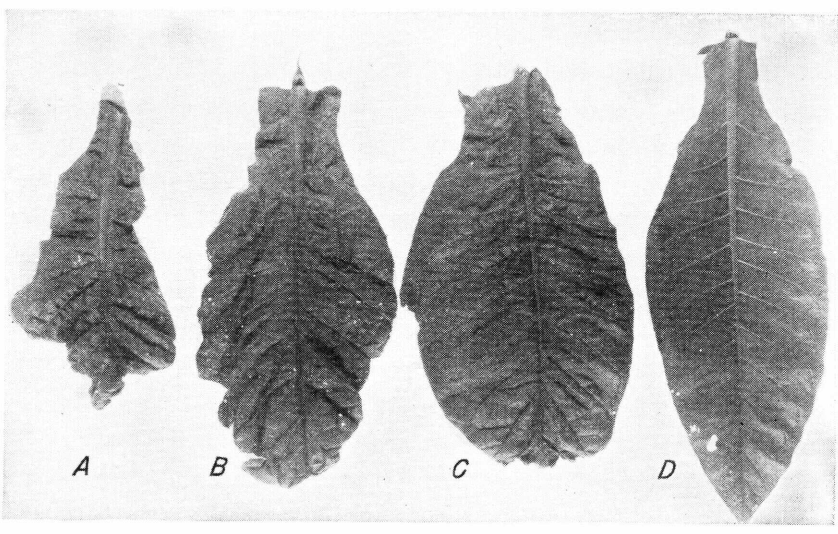


Figure 46.—Effect of calcium shortage on young leaves of tobacco plant: *A* to *C,* Young leaves showing abnormalities in growth; *D,* leaf from a normal plant.

acute at the flowering stage the floral parts (fig. 47, *B*) show certain abnormalities. The flower buds and blossoms often shed, and the remaining flowers show a dieback of the corolla, leaving the pistil protruding. The calyx lobes in most cases show spots of dead tissue at the lobe tips.

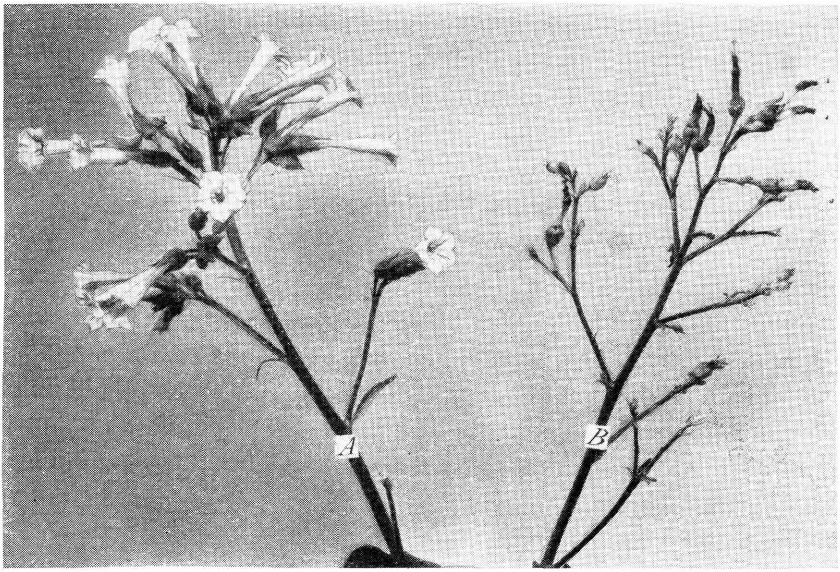


Figure 47.—Effects of calcium shortage on flowering parts of tobacco: *A*, Normal plant; *B*, corolla drying up and calyx distorted.

BORON DEFICIENCY

An acute shortage of boron first produces marked changes in the tip or growing point of the plant. The young leaves become light green, with a lighter green at the base of the leaf than at the tip. Such leaves have ceased to grow and show a somewhat drawn appearance. Next, the tissues at the base of the young leaves show signs of breakdown (fig. 45, *B*). If growth should take place later, before all the tissues are broken down, these leaves would be distorted by growth around the injured tissue. Such plants or leaves often show a one-sided or twisted growth.

The death of the terminal bud (fig. 39, *E*) follows these stages and brings about a topping of the plant, causing the leaves to thicken and increase in area. The upper leaves tend to roll in a half circle from the tip toward the base. They are abnormally light green in color and become smooth, stiff, and brittle. When the midrib or secondary veins are broken, their vascular tissues show a dark discoloration.

Lateral buds (suckers) may develop in the axils of the leaves or at the base of the stalk, but they commonly break down like the terminal bud. When boron shortage does not become acute until the flowering stage, the flower buds are shed and no seed pods are set.

The first visible symptom of manganese hunger is a loss of color in the young leaves. This loss of color follows out the most minute

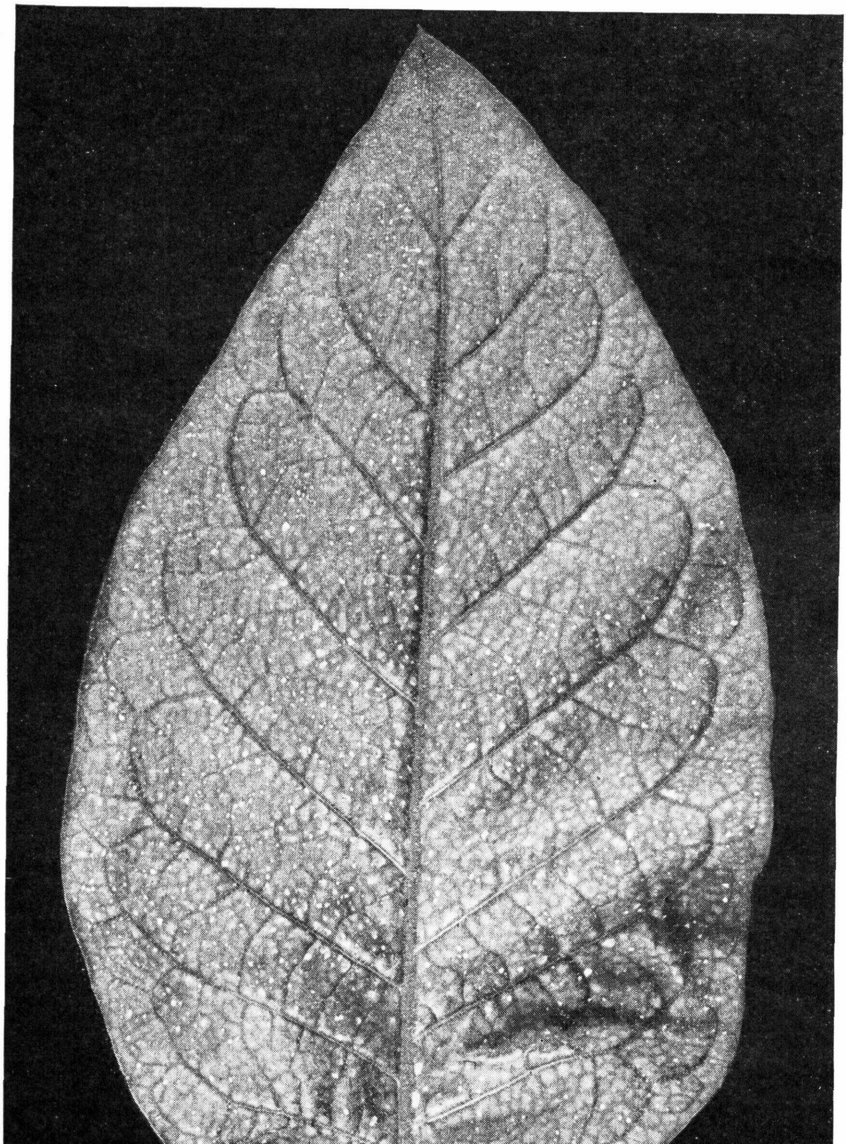


Figure 48.—Leaf, showing chlorosis and necrosis typical of manganese deficiency.

branches of the leaf veins. Between the veins the leaf is light green to almost white (fig. 48), while the veins retain a darker green color. The leaf has a checkered appearance because of the contrast between the green veins and the intervein areas that have lost their color.

The loss of color is followed by the development of spots of dead tissue that are small at first but later enlarge and drop out, giving the leaf a ragged appearance. Usually the spots are not confined to the tip and margins, as in the case of potassium deficiency, but are scattered over the entire leaf.

SULFUR DEFICIENCY

The first evidence of sulfur shortage is the light-green color of the plant as a whole, though there is a tendency for the young leaves to be lighter green than the older ones. Such plants do not lose their lower leaves by firing, as they do in the case of nitrogen shortage.

As a rule, the effects of sulfur deficiency under field conditions are apparent only in the early stages of growth and during dry periods. The leaves on such plants show a characteristic crimping downward at the tips and margins (fig. 49, *B*). Recovery often takes place rapidly and completely when rains wash the sulfur commonly carried in the air into the soil.

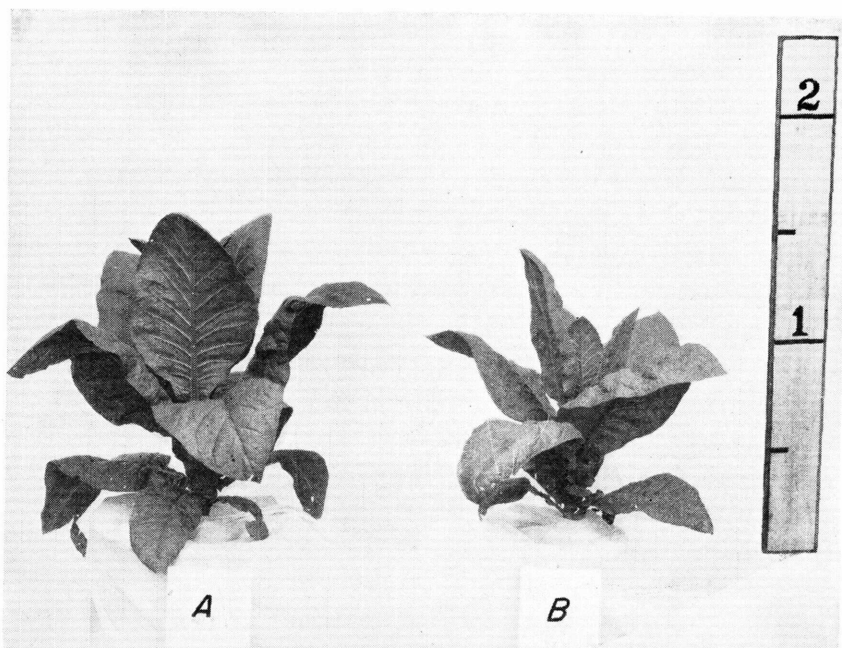


Figure 49.—Effect of sulfur supply on growth: *A*, Tobacco plant normal in appearance and growth; *B*, plant showing effects of sulfur shortage on growth.

Good growth of tobacco plants and control of seedling diseases due to shortages of chemical elements essential for plant growth are commonly avoided by broadcast applications incorporated in the upper 2 inches of soil applied in the proportion of 1 pound per square yard of various mixtures, such as a 6–9–3 fertilizer.

The rate of applications and the composition of the mixture may be varied to advantage, depending upon other treatments previously mentioned under urea and cyanamide seedbed treatments.

The 6 percent of nitrogen (N) may be derived from mixed sources; phosphoric acid (P_2O_5) is commonly from superphosphate; and the potash (K_2O) from sources that are free of chlorides. Excess chlorine from any source causes injury to growth of young seedlings, characterized by thickening of the leaves and stunting of the young plants. The addition of 1 percent available magnesia (MgO) prevents magnesium deficiency, which has frequently been observed, and its inclusion is recommended for seedbeds on sandy soils. Excessive application of readily soluble fertilizers often causes injury during dry periods, becoming evident as stunting, or even killing, of the young seedlings. Top dressings of various materials, such as nitrate of soda, urea, cottonseed meal, and sheep manure, are often used to advantage when nitrogen or other deficiencies become evident. It is important to wash these materials from the leaves of the young seedlings to avoid injury.

Malnutritional diseases are controlled and tobacco is grown to best advantage under controlled fertilization. This is particularly true of flue-cured tobacco, where rather definite amounts of nitrogen (N), phosphorus (P_2O_5), and potassium (K_2O) must be supplied. In addition, many soils should receive calcium (CaO), magnesium (MgO), sulfur (SO_3), and chlorine (C1) in order to get best results. A fertilizer formula approximating 3–9–10–6–2–8–2 percentages of these elements, in the order given above, when applied at the rate of 800 to 1,200 pounds per acre, will give good results on most soils.

The fertilizer application to Maryland, cigar-filler, cigar-binder, burley, dark air-cured, and fire-cured types may have much the same formula with respect to nitrogen, phosphorus, and potassium. The rate per acre may be around 750 pounds, more or less. The amount of fertilizer used in the cigar-tobacco-producing areas of Connecticut and Florida may be as much as a ton to a ton and a half of a 6–5–6. Manure may be used with all these types, with reductions in the fertilizer applied. Applications of chlorine because of its unfavorable effect on fire-holding qualities of the leaf should be held to a minimum with all these types.

Sources of the several elements in the fertilizer mixture are numerous and varied. The sources of nitrogen, phosphorus, and potassium should be so selected as to supply the required amounts of calcium, magnesium, sulfur, and chlorine.

The nitrogen is usually derived from mixed sources. Superphosphate, double or treble superphosphate, and dicalcium phosphate have been found to be satisfactory sources of phosphorus. The potassium may be derived from any source provided the chlorine content of the

mixed fertilizer be about 2 percent for flue-cured tobacco and held to a minimum for other cigarette, cigar, and smoking tobaccos.

Boron, when necessary, may be applied at one-half pound per acre as either borax or boric acid. Manganese, copper, and zinc, at around 1 to 2 pounds per acre, may be supplied as sulfates on normal soils that are usually acid. When required on neutral or alkaline soils these amounts will need to be increased. Excesses of any of these elements are to be avoided; for example, as little as 1 pound per acre of boron applied in the row may retard the growth of tobaccos.

The method of fertilizer application and its effect on survival and growth of the tobacco plant are important. Applications to only one side of the plant frequently produce a one-sided growth or deficiency symptom. Application of the fertilizer in bands on both sides of the plant 1 inch below the root crown has consistently resulted in highest survival of transplants, as well as the best final yield and quality. Delayed applications of fertilizer should not be much in excess of 21 days after transplanting to obtain best results.

KEY TO MALNUTRITIONAL DISEASES OF TOBACCO

(Showing element that should be supplied to cure symptoms)

				Elements to be supplied
Decreased growth, localized effects; causal parasites or viruses absent.	Group 1: Effects general on whole plant; or localized on older or lower leaves of plant.	General on whole plant; also, yellowing and drying up or firing lower leaves.	Plant light green. Lower leaves yellow and dry to light brown. Stalk short and slender if element is limiting in later growth stages (fig. 39, *B*).	Nitrogen.
			Plant dark green. Lower leaves may yellow and dry to a greenish brown to black. Stalk short and slender if element is limiting in the later growth stages (fig. 39, *C*).	Phosphorus
		Local, as mottling or chlorosis, with or without necrotic spotting of lower leaves, little or no drying up of lower leaves.	Lower leaves mottled with necrotic spots at tips and margins, which are tucked or cupped under. Stalk slender in extreme cases and may show necrotic areas (figs. 39, *D*, 41, and 42).	Potassium
			Lower leaves chlorotic and typically show no spots. Tips and margins turned or cupped upward. Stalk slender in extreme cases (figs. 39, *C*, 43, and 44).	Magnesium.
	Group 2: Effects localized on newer or bud leaves of plant.	Terminal bud dies; death is preceded by peculiar distortions at the tips or bases of young leaves making up bud.	Young leaves making up terminal bud first typically hooked; then die back at tips and margins so that later growth of such leaves shows a cut-out appearance at tips and margins. Stalk finally dies back at terminal bud (figs. 39, *E*; 45; *A*, 46, A–C; and 47, *B*).	Calcium.
			Young leaves making up terminal bud first light green at base, then more or less breakdown takes place at base of young leaf, and if later growth follows leaf shows twisted growth. Stalk finally dies back at terminal bud (figs. 39, *E*, and 45, *B*).	Boron.
		Terminal bud remains alive; chlorosis of newer or bud leaves, with or without necrotic spots; veins light or dark green.	Young leaves chlorotic, with necrotic spots scattered over leaf. Smallest veins tend to remain green, producing a checkering effect on leaf. Stalk slender (fig. 48).	Manganese
			Young leaves light green, no necrotic spots. Veins lighter green than intervein tissues. Stalk short and slender (fig. 49, *B*).	Sulfur.

LIBRARY
CURRENT SERIAL RECORD
JAN 3 1951
U.S. DEPARTMENT OF AGRICULTURE

U. S. GOVERNMENT PRINTING OFFICE: 1950